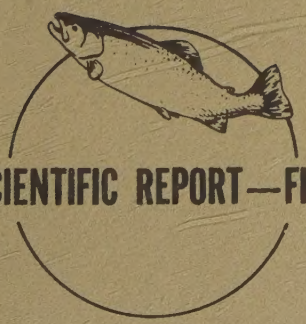
Longline and Troll Fishing for Tuna in the Central Equatorial Pacific, January 1955 to February 1956



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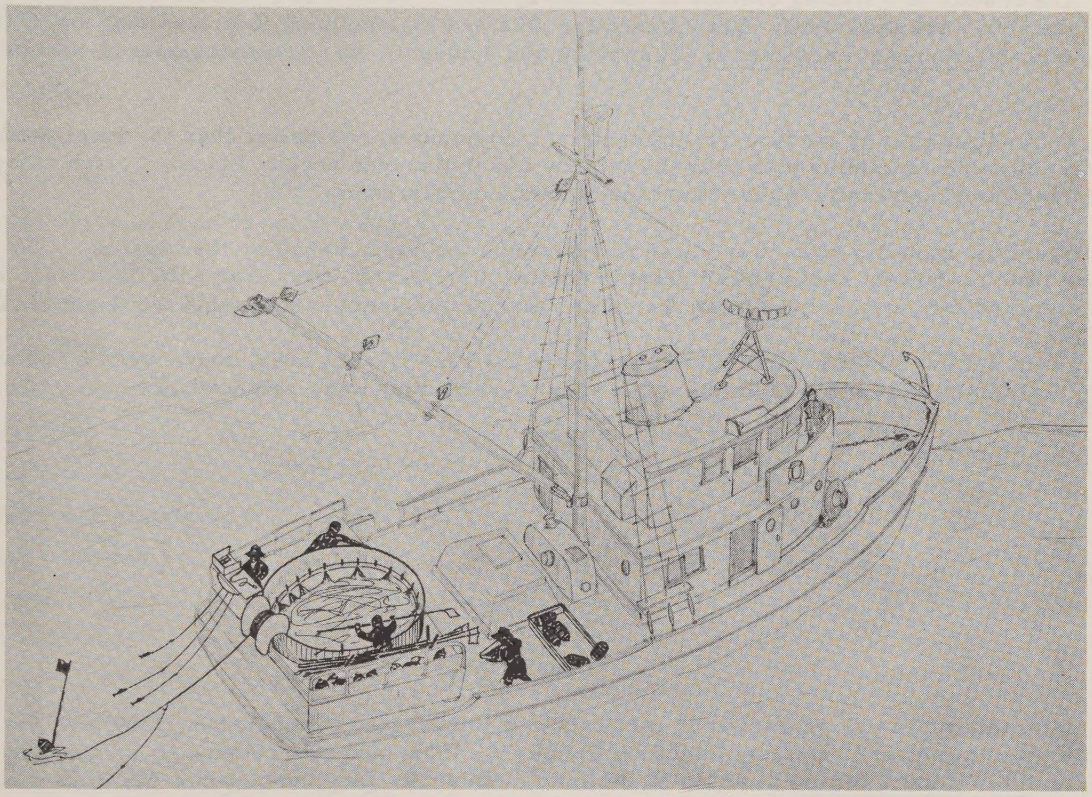

LONGLINE AND TROLL FISHING FOR TUNA IN THE CENTRAL EQUATORIAL PACIFIC, JANUARY 1955 TO FEBRUARY 1956

By

Edwin S. Iversen

and

Howard O. Yoshida
Fishery Research Biologist
Pacific Oceanic Fishery Investigations
Honolulu, T. H.

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ABSTRACT

The results of 9 fishing cruises to the Line Islands area by POFI vessels during March 1955 to February 1956 are discussed. The catch rates obtained by longlining indicated that the abundance of yellowfin, Neothunnus macropterus (Temminck and Schlegel), was low as compared with previous years.

Yellowfin caught by surface trolling close to the islands were smaller than the deep-swimming yellowfin caught by longlining both near the islands and in the open ocean. Longline catch rates close to the islands were generally higher than their oceanic counterparts.

Chemical sounding tubes were used to determine the depth fished by the longline. The data indicated that the deepest hooks fished greater depths at 5° to 6°N. than near 1°N. latitude. There was no significant relationship between the catch rates on the deepest hooks and the depth of fishing.

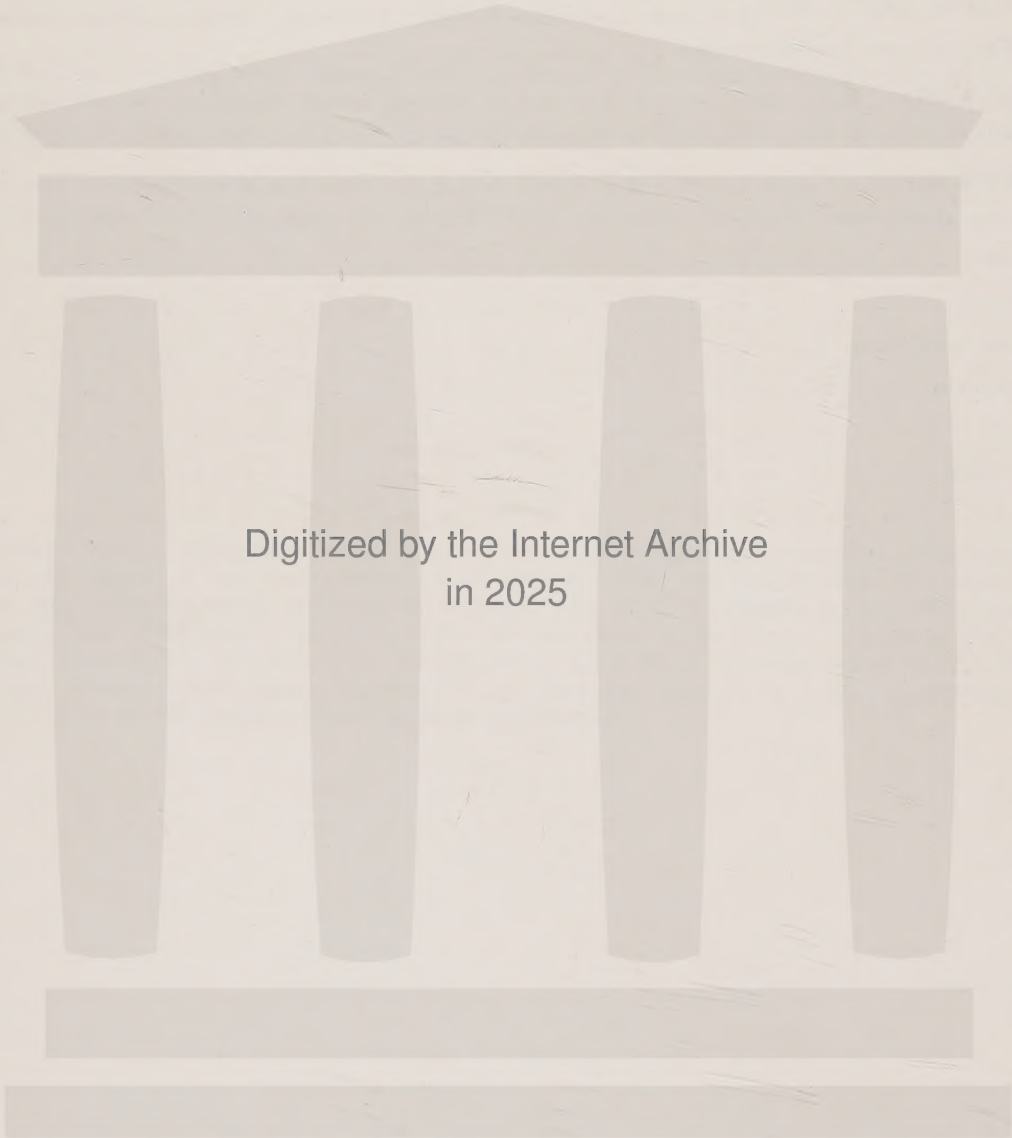
From 1,056 yellowfin captured and tagged in the Line Islands area, there were 2 recoveries prior to September 1956, both from the same area in which they were released.

NOTE

After this paper was prepared for publication, a third tagged yellowfin (No. 3350) was recovered. This fish was tagged at Christmas Island on October 8, 1955, and was retaken by a Japanese longliner, the No. 7 Sakura Maru, at 02°45'N. latitude, 143°20'W. longitude, some 800 miles east of Christmas Island on November 10, 1956. The fish had been at liberty for 13 months and during this period grew from 111.0 cm. (58.7 lb.) to 139.0 cm. (95.8 lb.). Perhaps even more significant, the fish had abandoned the island habitat for the open sea, and there is the implication that it had changed its mode of life from surface- to deep-swimming.

CONTENTS

	Page
Acknowledgments	1
Description and operation of gear	2
Trolling	2
Longlining	2
Depth reached by longline gear	3
Effect of depth of gear on catch rates	6
Catch composition	6
Trolling	7
Longlining	7
Yellowfin tuna abundance	7
Trolling	7
Longlining	10
Japanese longlining	10
Tagging program	10
Summary	12
Literature cited	12
Appendix	14



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ILLUSTRATIONS

FIGURE Page

Frontispiece: Diagram showing longline setting procedure from a tub aboard the John R. Manning

1. Comparison of yellowfin catch rates on steel and cotton gear and comparison of catch rates between two vessels fishing simultaneously in the same area. . . . 3

2. Catch rates for three size classes of yellowfin captured on cotton and steel longline gear on John R. Manning cruise 24. 3

3. Depth of various hooks on single baskets of longline, as determined by sounding tubes. 4

4. Latitudinal variation in depth of the deepest hooks on longline sets, as determined by sounding tubes, 157°48'W.-161°57'W. longitude, John R. Manning cruise 27, October 1955. 5

5. Variation in average depth of the deepest hooks on longline sets in relation to time of year, 1955-56. 5

6. Relationship of the average depth of the deepest hooks of longline sets and yellowfin catch rates. 6

7. Length frequency distributions of oceanic and insular yellowfin caught by longlining and trolling. 7

8. Yellowfin troll catch rates in the Line Islands arranged by time of day. 9

9. Yellowfin troll catch rates in the Line Islands March 1955 to February 1956. 9

10. Relationship of yellowfin troll catch rates to areas, Line Islands, March 1955 to February 1956. 9

11. Daily yellowfin longline catch rates in the Line Islands, 1955-56. 10

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Edwin S. Iversen[1/]

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Howard O. Yoshida
Fishery Research Biologist
Pacific Oceanic Fishery Investigations
Honolulu, T. H.

The Pacific Oceanic Fishery Investigations (POFI) of the U. S. Fish and Wildlife Service is conducting a survey of the tuna resources of the central Pacific. This report is concerned with the distribution and abundance of yellowfin tuna in the Line Islands region from January 1955 to February 1956, as determined by longline fishing and surface trolling. Summaries of results to date on the general study of yellowfin abundance are included, together with a report on the progress made in a tagging program. In addition, the results of Japanese commercial longline fishing in the equatorial region during 1955 are briefly discussed.

Seven reports on POFI longline tuna fishing in the central equatorial region have been published. The first five[2/] describe the results of exploratory longline operations and provide general information on the biology of the yellowfin, its abundance and distribution. They also include studies of the longline as a sampling tool, together with suggested changes for greater efficiency. The most recent report on fishing in this area (Iversen and Yoshida 1956) described the results of the first commercial attempts to operate longlines in the Line Islands region.

The nine cruises which form the subject of this report involved troll and longline fishing in the Line Islands area by POFI vessels. These cruises were planned to provide, as nearly as possible, standardized observations on fishing over a period of approximately one year. It was hoped that information would be obtained to answer some of the questions raised by the outcome of the commercial expeditions of 1954 on the feasibility of commercial tuna fishing in the Line Islands area. Answers to these questions require (1) abundance estimates of the tuna population from a commercial viewpoint, (2) further insight into the interaction between the environment and the tuna, and (3) information on migration to be obtained by tagging. Tagging is the most promising method of demonstrating the relationship between small yellowfin frequenting the coastal areas of the various islands and the larger, more oceanic deep-swimming yellowfin, and the degree of association of the Line Islands population with that of the rest of the Pacific.

Daily sea surface temperatures taken at the weather station at Christmas Island during the period of this study are available. The data indicate that the sea surface temperature was unusually cold at Christmas Island during 1955. The significance of this phenomenon in relation to yellowfin catches is still being examined and will be discussed in other POFI reports.

The dates of the cruises are listed in table 1. As only a portion of cruise 19 of the Charles H. Gilbert was devoted to fishing in the Line Islands area, the results have not been analyzed here, although catch rates are given in the Appendix. Cruise 25 of the Charles H. Gilbert deviated from the standard pattern by occupying a line of stations from 6°N. to 4°S. latitude on 160°W. longitude, just west of the Line Islands. Catch records and scientific names of fishes discussed in this report are given in the Appendix.

ACKNOWLEDGMENTS

Appreciation is expressed to the officers and crews of the vessels Commonwealth, John R. Manning, and Charles H. Gilbert for their willing cooperation extending in many instances well beyond the required performance of their duties. Similarly, to the scientists and aids who assiduously gathered the information contained herein, we extend our thanks.

[1/] The Marine Laboratory, University of Miami, Coral Gables, Florida (formerly Fishery Research Biologist, U. S. Fish and Wildlife Service, Honolulu, T. H.)

[2/] Murphy and Shomura 1953a, 1953b, 1955, Murphy and Elliott 1954, and Shomura and Murphy 1955.

Table 1.--Line Islands fishing surveys, January 1955 to February 1956

Vessel	Cruise No.	Cruise dates	
		From	To
		1955	
Charles H. Gilbert	19[1/]	January 20	February 19
Charles H. Gilbert	20	March 7	April 21
John R. Manning	24	March 24	April 15
Commonwealth	3	May 7	June 17
Commonwealth	4	July 6	August 17
Commonwealth	5	September 9	October 15
John R. Manning	27	September 26	October 29
John R. Manning	28	November 19	December 17
		1956	
John R. Manning	29	January 5	February 15
Charles H. Gilbert	25	January 16	February 13

[1/] Not discussed; catch rates in Appendix.

DESCRIPTION AND OPERATION OF GEAR

Trolling

The trolling gear consisted of two booms, one mounted on either side of the vessel, each carrying two or more (usually three) cotton trolling lines. The lures were the common feather jigs (lead and plastic heads), plastic lures, bone type jigs, plugs, and spoons. A complete description of the method and equipment is given by Bates (1950).

Surface trolling was done close to the several islands of the Line Islands group, usually within 3 miles of the reefs. Although the islands were often circled during the trolling operations, the majority of the fishing was carried out at the boundaries of the eddies and in the lees of the islands, for yellowfin appeared to be more abundant there than on the windward sides. Bates (1950) also found this to be true.

Longlining

The other method employed to sample the abundance of yellowfin was longlining. The type of longline gear used in 1955-56 has been described in detail by Mann (1955). Briefly, each basket was composed of a 210-fm. mainline with 10-fm. float lines; the 11 branch lines or droppers were 3 fm. in length and were spaced at 15-fm. intervals.

For comparison with previous years when 6-hook gear was standard, a conversion factor must be applied to the 11-hook catch rates. Shomura and Murphy (1955) have shown that the catch rates of yellowfin on gear with 11 hooks per basket are consistently lower than on 6-hook gear and should be multiplied by 1.52 to make them equivalent.

Studies on the improvement of longline gear for greater operational efficiency continued along two lines. First, an improved method of handling fabric gear to replace the present method of storing the gear in individual units or baskets was tested. This innovation consists of coiling the entire mainline into a large revolving tub (frontispiece). Float lines and dropper lines are attached when the gear is set and removed when it is retrieved. While the time required to handle gear by this new method is about the same as for the conventional Japanese method, less manpower is needed.

The second attempt at improvement involved the use of a mainline constructed of small-diameter wire rope. The results of its use on cruise 24 of the John R. Manning were not particularly encouraging because of operational difficulties. There was, however, no indication of a significantly lower catch rate on steel gear than on fabric gear (fig. 1), as had been observed in the past. Comparison of catch rates by these two gear types during 1954 showed that the steel gear caught fewer fish, partly because of the loss of larger fish due to the low resilience of the steel mainline gear (Iversen and Yoshida 1956). The size of yellowfin caught on both gear types was similar during 1955 (fig. 2). Despite the similarity in the 1955 catch rates for the two gear types, it does not seem that steel gear has sufficient superior operational characteristics to warrant continued experimentation. This conclusion is based on an unpublished analysis by POFI scientists in which cost, time, and labor were considered.

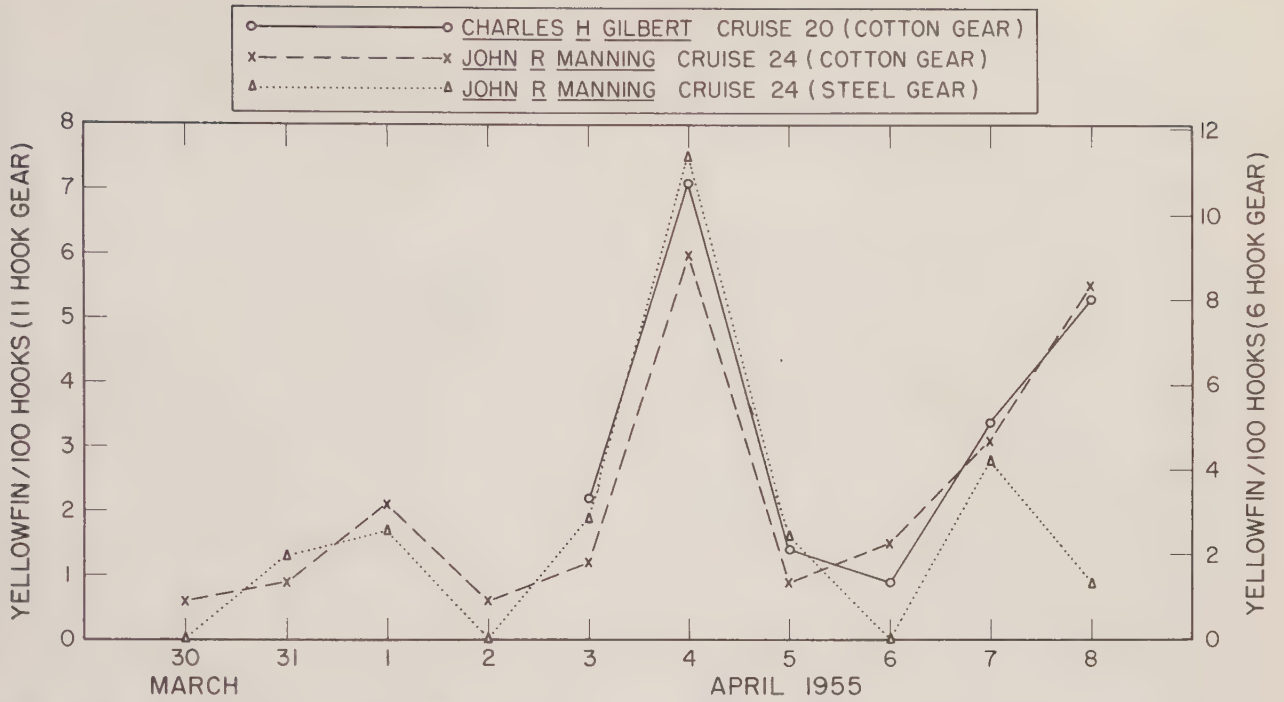
CHARLES H GILBERT CRUISE 20 (COTTON GEAR)
JOHN R MANNING CRUISE 24 (COTTON GEAR)
JOHN R MANNING CRUISE 24 (STEEL GEAR)
YELLOWFIN/100 HOOKS (11 HOOK GEAR)
YELLOWFIN/100 HOOKS (6 HOOK GEAR)
30 31 1 2 3 4 5 6 7 8
MARCH
APRIL 1955

Figure 1.--Comparison of yellowfin catch rates on steel and cotton gear and comparison of catch rates between two vessels fishing simultaneously in the same area (data in Appendix tables 17 and 18).

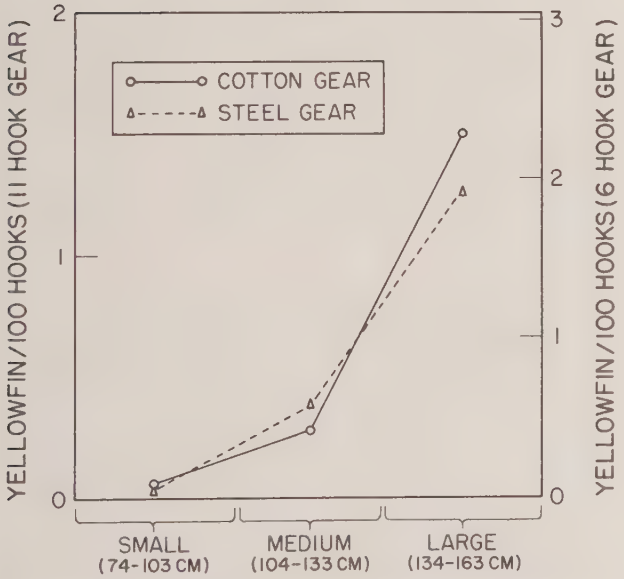

Figure 2.--Catch rates for three size classes of yellowfin captured on cotton and steel longline gear on John R. Manning cruise 24.

It is of considerable importance to have an evaluation of the variation in catch rates between vessels. The Charles H. Gilbert during cruise 20 and the John R. Manning during cruise 24 fished simultaneously within 20 miles of one another from April 3 through April 8. Figure 1 shows that the catch rates of both vessels agree very closely. This same conclusion was drawn from the catches of commercial vessels fishing together in this area during 1954 (Iversen and Yoshida 1956). Therefore, we do not believe that variation among vessels was a distorting factor in our examination of differences among seasons, areas, etc.

It has been previously shown that close to islands (within 80 miles of land) yellowfin catch rates on longline gear were higher than at distances greater than 80 miles (Shomura and Murphy 1955). Since there appears to be a population of small yellowfin intimately associated with islands, in this study the line of demarcation between "oceanic stations" and "insular stations" has been placed at 10 miles from land.

DEPTH REACHED BY LONGLINE GEAR

Knowledge of the depth at which longline gear is fishing is important since there appears to be a differential catch rate by hook depth, with the better catches usually made on the deeper hooks. This variation was observed by Nakamura (1949) and was reported previously in the various POFI longline reports. Prior to 1955 depth measurements of the mainline were

obtained by "pressure gauges" (Murphy and Shomura 1953b) and by using a Bendix Echo Sounder (Murphy and Shomura 1955). Neither of these methods was satisfactory, so other means have been sought. Beginning with the first longline cruise of 1955, glass sounding tubes were used regularly.

The sounding tubes which we have employed are 24 inches in length, 1/8 inch in diameter, and are coated on the inside surface with a water soluble chemical. Before placing the tube in the water, one of the sealed ends is broken. As the tube is lowered pressure forces water into the open end of the tube, dissolving the chemical adhering to the inside surface over a distance proportional to the depth. In operation the glass tubes were placed in metal tubes which were attached to the branch lines (droppers). At the time the gear was set one end of the sealed tube was broken off and the tube was placed into the holder with the open end down. When the gear was retrieved the fishing depth was obtained by measuring the distance from the closed end of the tube to the line formed by the dissolved chemical. A close correspondence has been found between the depth readings of sounding tubes and of bathythermographs when the two instruments were lowered simultaneously to the same depth and immersed for 5 to 10 hours (Shomura and Otsu 1956).

The chemical sounding tubes disclosed considerable variation in the depth of the deepest hooks between sets of longline in the Line Islands area. The reasons for this variation are not understood but by examining each source of variation independently we can offer possible explanations for different gear behavior under different circumstances. Variation in the depth of different hooks within a single basket, variation in depth of the deepest hooks on representative baskets within a set, and variation in depth of the deepest hooks between stations all merit examination.

At some stations sounding tubes were placed on different hooks of individual baskets. The depths recorded for the various hooks have been plotted in figure 3. (Data in Appendix table 7, Charles H. Gilbert cruise 20, stations 13, 15; cruise 25, stations 7, 10; Commonwealth cruise 3, station 5; cruise 4, station 11). The only fish taken on these test baskets that could conceivably affect the results was a brown shark caught on hook number 3 (Commonwealth cruise 4). No explanation is offered for the number 10 hook reading of 100 fm. It appears from the lines drawn in figure 3 that there was greater variation in the depth of the deeper hooks than

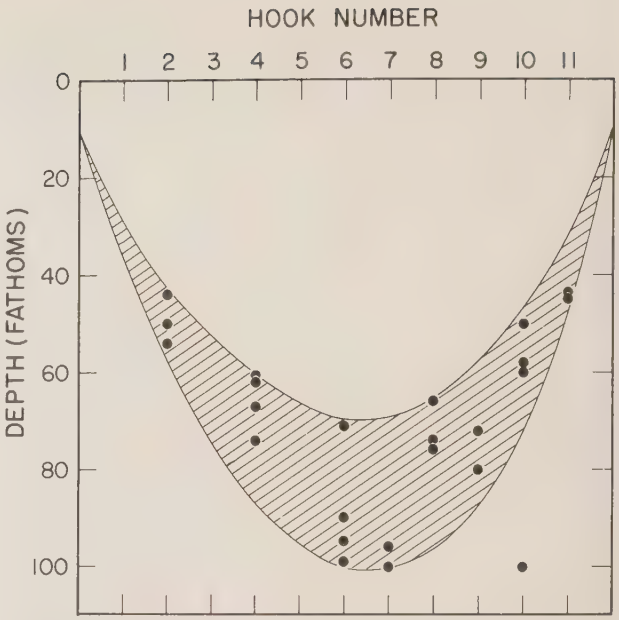

Figure 3.--Depth of various hooks on single baskets of longline, as determined by sounding tubes (data in Appendix table 7, Charles H. Gilbert cruise 20, stations 13, 15; cruise 25, stations 7, 10; Commonwealth cruise 3, station 5; cruise 4, station 11).

of the shallower hooks. A streaming of the line has been suggested as the reason for the lesser depths reached by the deepest hooks in the area just north of the Equator (Murphy and Shomura 1955) and it appears reasonable that the strong currents of this region could have produced this effect. These results provide an exemplification of the theoretical model of the effect of altering buoy distance on the depth of hooks on longline gear as shown by Murphy and Shomura (1953: fig. 5, p. 8).

An examination of the depth of the deepest hooks on baskets within individual sets (table 7, Appendix) in the majority of cases shows no important differences among baskets. The distance between buoys, varied by different setting speeds, can affect the depth of the mainline and in turn the hook depth. Unfortunately there is no simple, reliable method of accurately determining the distance between buoys. Murphy and Shomura (1955) have made some measurements by radar and found that usually the buoys were 900-1,100 ft. apart. While we did not measure this interval during the 1955-56 cruises, distances between the buoys in some cases theoretically should be less than this in order to obtain depth readings of 90-100 fm. with baskets composed of 210-fm. mainlines, 10-fm. float lines and 3-fm. branch lines.

There is evidence of a rather wide variation in the depth of the deepest hooks among sets within cruises. Although the method of setting and retrieving the gear was standard on cruise 27 of the John R. Manning, it can be seen that the deepest hooks reached greater depths at 5° to 6°N. than near 1°N. latitude (fig. 4). This difference possibly resulted from the shear between the westerly South Equatorial Current at the surface and the easterly Equatorial Undercurrent beneath. The Equatorial Undercurrent is usually encountered within approximately 2 degrees of latitude of the Equator in the central Pacific (Cromwell et al. 1954). These conclusions are supported by the observed drift of the gear and vessels on fishing stations.

Differences in the depth of the deepest hooks are as large as 40 fm. from north to south. During October and November 1952, at stations between 7° and 9°N. latitude, Murphy and Shomura (1955) found mean depths for the deepest hooks at about 300 ft., as measured by the echo-sounding method, whereas we obtained a figure closer to 500 ft., employing sounding tubes in October 1955. At stations near the Equator we both found the mean depth to be approximately 200 ft. Murphy and Shomura (1953b, table 16) present data obtained with "pressure gauges" on longline sets along

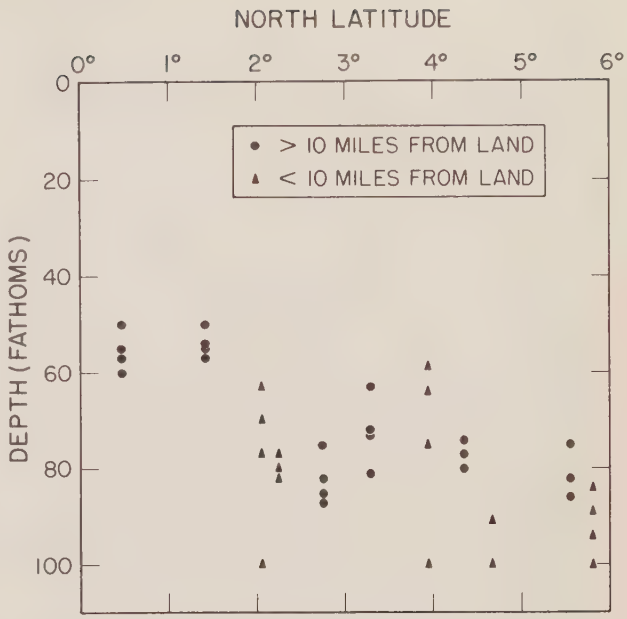

Figure 4.--Latitudinal variation in depth of the deepest hook on longline sets, as determined by sounding tubes, 157°48'W. - 161°57'W. longitude, John R. Manning cruise 27, October 1955.

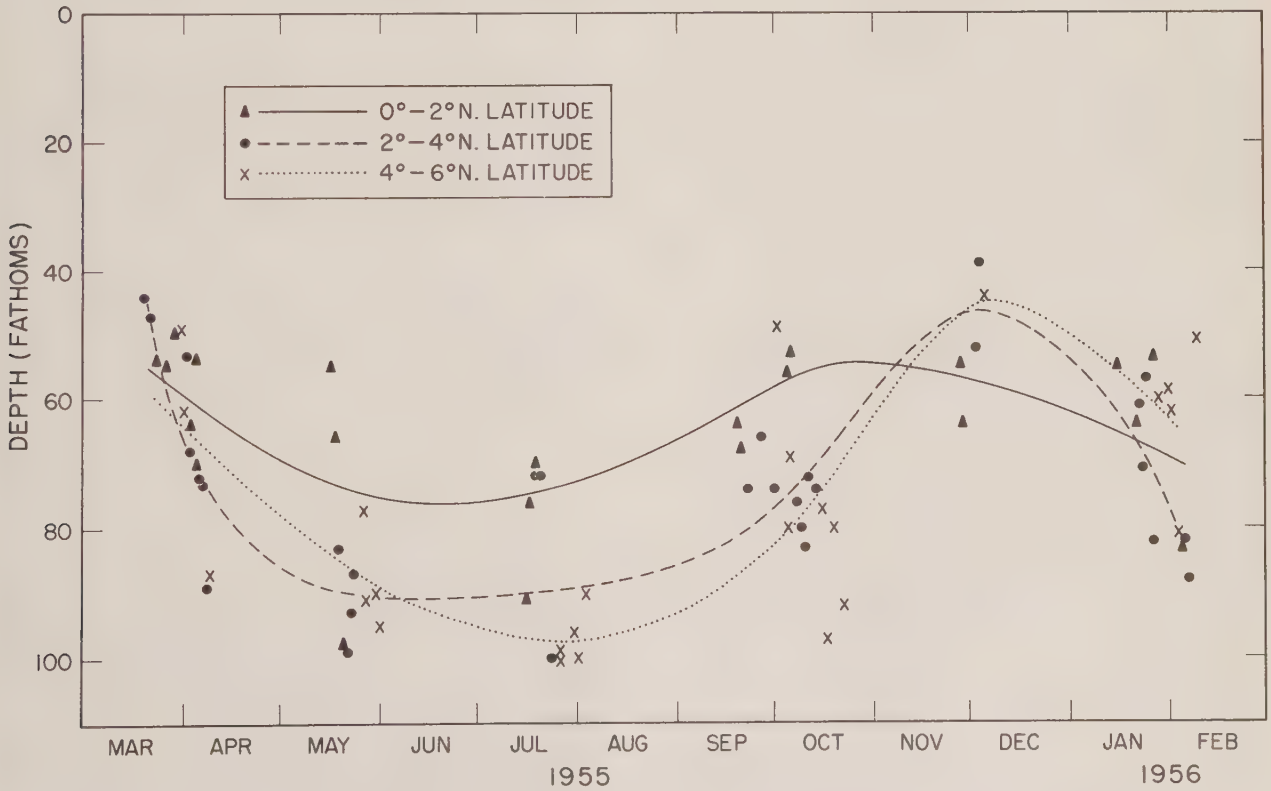

Figure 5.--Variation in average depth of the deepest hooks on longline sets in relation to time of year, 1955-56.

170°W. longitude during March 1952 which allow the same conclusion, i.e., the longline gear appears to sink deeper at several degrees north of the Equator than in the immediate vicinity of the Equator. The deepest hooks at the Equator reached 285 ft.; at 1°21'N., 300 ft.; at 2°51'N., 455 ft.; and at 4°10'N., 520 ft.

The depth of the deepest hooks varies with time throughout the year. Figure 5 shows trend lines drawn by eye through the average depths of the deepest hooks of longline sets with respect to time for three arbitrarily selected areas, 0°-2°N., 2°-4°N., and 4°-6°N. latitude. In each of these areas there is an indication that the variation with time is of generally similar magnitude and seasonal pattern for the various cruises. Although some of the variation within months may be the result of different operational procedures by the different vessels, it would seem that seasonal changes in current direction and velocity might be primarily responsible for the major variation in hook depth throughout the year.

There is some indication that the depth of the deepest hooks on the longline gear is also affected by peculiar current conditions immediately surrounding islands. In general the average depth of sets made less than 10 miles from islands was slightly deeper than those farther than 10 miles from land (fig. 4). We can only speculate on the cause for this, but it seems reasonable that in some locations near islands the current velocity was reduced and this in turn allowed the gear to reach a greater depth. Such a situation could conceivably have existed in the lees of the islands or perhaps upstream where the islands had a damming effect.

EFFECT OF DEPTH OF GEAR ON CATCH RATES

While it has been known for some time that the catch rates of yellowfin are generally higher on the deeper fishing hooks, we have not previously had measurements to determine the absolute depth of the gear. Now that we have these measurements at each longline station, we have examined the variation in catch rates among sets to see if it were related to differences in hook depth. In figure 6 we have plotted the yellowfin catch rates against the average depth of the deepest hooks of longline sets. Stations where there was only one depth determination available and stations where no yellowfin were caught were not plotted. The data show considerable variation in both depth of the sets and catch rates. Looking first at the oceanic stations, the highest catch rates were obtained at stations where the deepest hooks fished at

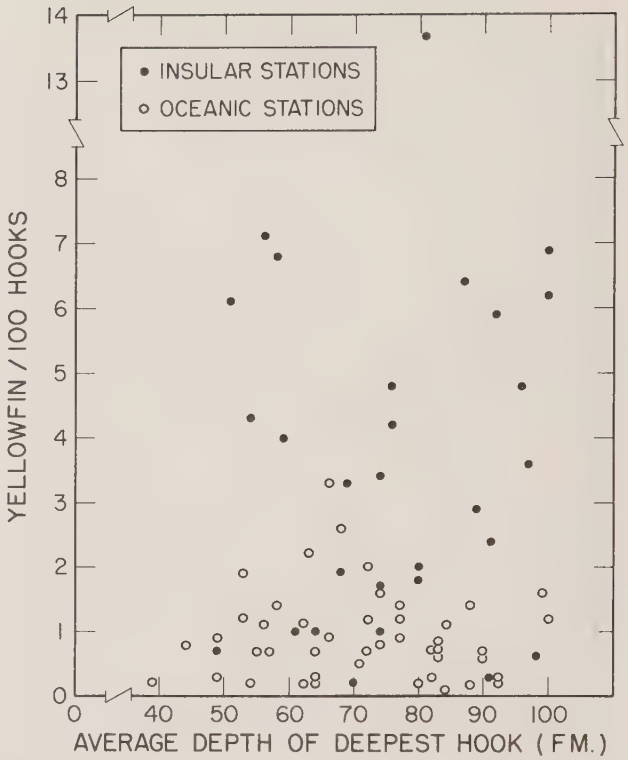

Figure 6.--Relationship of the average depth of the deepest hooks of longline sets and yellowfin catch rates.

depths averaging between 60 and 80 fathoms. Any further conclusions about fishing depths that may be offered now would be mere conjecture, but perhaps with more data it would be possible to more clearly delimit the optimum fishing depth for yellowfin in this area.

The insular catch rates were generally higher than the oceanic catch rates regardless of the depth of the gear. This suggests that there are actually greater numbers of yellowfin close to islands and that the catch rates are not necessarily related to the depth of fishing, at least within the depths that we sampled.

CATCH COMPOSITION

Different habitats were sampled by the two fishing methods and the species and size composition of the catches varied with the locality and method of capture. Trolling near the various islands yielded, in addition to tunas, fishes associated with the reefs in the upper layers of the sea. Longlining, on the other hand, sampled the deeper strata in the ocean at distances greater than 5 miles from land and caught larger pelagic fishes for the most part.

Trolling

By means of surface trolling 2,397 fish were captured from January 1955 to February 1956. Of this number 980 (40.9 percent) were yellowfin tuna and 43 (1.8 percent) were skipjack. Most of the remainder were wahoo (1,160 or 48.4 percent), and there were 214 (8.9 percent) miscellaneous fish including rainbow runner, jack, dolphin, barracuda, red snapper, little tunny, needlefish, leatherjacket, and sharks.

The yellowfin caught by trolling ranged from 50 cm. (5 lb.) to 151 cm. (148 lb.). The size-frequency distribution of these catches shows a single mode at the 70-79 cm. class interval (fig. 7). Bates (1950) reported the presence of a pronounced mode between 70 and 75 cm. (15 to 18 lb.) and another near 110 to 115 cm. (57 to 65 lb.) in the size distributions of troll-caught yellowfin from the Line Islands (April to June 1950).

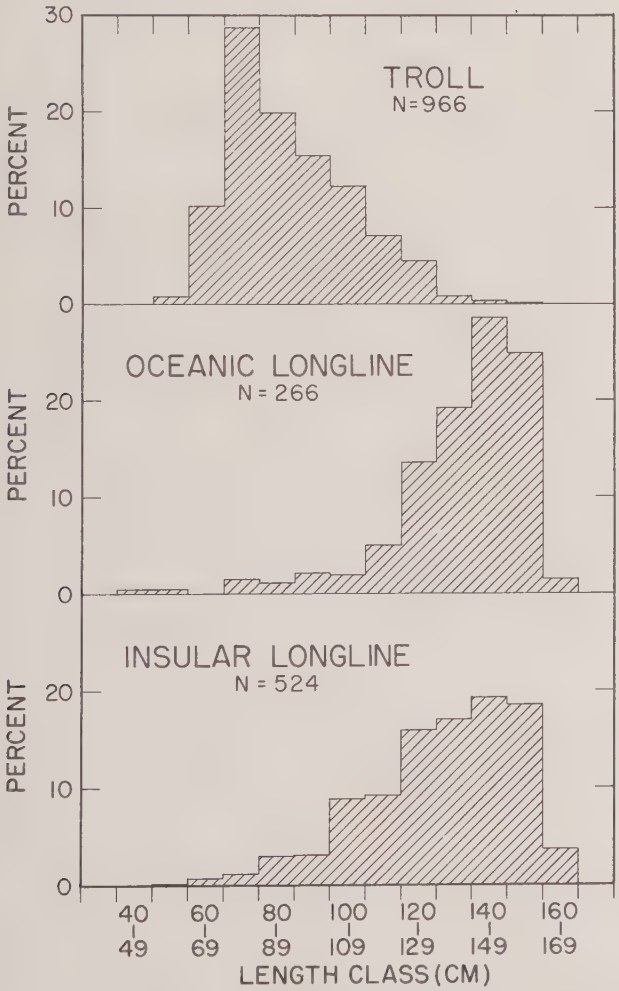

Figure 7.--Length frequency distributions of oceanic and insular yellowfin caught by longlining and trolling (data in Appendix, table 5).

Longlining

The longline catches yielded 2,215 fish; of these, yellowfin totaled 1,002 (45.2 percent), bigeye 31 (1.4 percent), skipjack 32 (1.4 percent), and sharks[3/] 1,051 (47.4 percent). The remainder of the catch, 99 fish (4.5 percent), was composed of small numbers of marlin, broadbill, sailfish, dolphin, wahoo, barracuda, lancet fish, sunfish, and puffer. No albacore were caught during these cruises. The absence of albacore is interesting because some albacore were taken on nearly all previous cruises to this area.

The size of the oceanic yellowfin ranged from 47 cm. (4 lb.) to 163 cm. (186 lb.). The size distribution shows a single modal group with a mode located at the 140-149 cm. class interval (fig. 7). The frequencies in the class intervals below the mode drop sharply with each smaller class interval.

The size of the insular yellowfin ranged from 56 cm. (8 lb.) to 163 cm. (186 lb.). The size distribution shows a single mode, also located at the 140-149 cm. class interval (fig. 7). This distribution indicates that there were more small fish present in relation to the large than in the case of the oceanic catches. This substantiates previous findings that there are more small yellowfin close to islands than in the open sea.

The ratio of male to female yellowfin was 2.26:1.00, which is consistent with past observations.

YELLOWFIN TUNA ABUNDANCE

Trolling

Beginning with cruise 20 of the Charles H. Gilbert surface trolling was made a regular part of the equatorial program to (1) supplement our biological knowledge of the yellowfin, (2) provide small yellowfin for tagging, and (3) provide another measure of abundance of yellowfin. Prior to 1955 only occasional trolling surveys had been made in the central equatorial Pacific and then usually as a secondary operation to longline fishing surveys. Since the early surveys were not continuous throughout the year there

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3/ The various species of sharks were lumped under this general heading both here and in the Appendix, tables 17 to 25. These include brown sharks, white-tipped sharks, great blue sharks, thresher sharks and bonito sharks.

was uncertainty about the commercial value of such fishing in this region. Bates (1950) concluded that the Line Islands' population of yellowfin was sufficiently abundant during the spring of 1950 for commercial exploitation by limited fishing effort. The results of occasional surveys by trolling in the Line Islands are briefly reviewed by Murphy and Ikehara (1955). These authors utilize the catch rates of Bates (1950) and later surveys by POFI vessels amounting to 890 line hours in the Line Islands area (defined as 0-60 miles from land) and compare them with yellowfin catch rates reported from Hawaii by Welsh (1950) and Tester (1952). Murphy and Ikehara's analysis shows a higher catch rate of yellowfin from the Line Islands than from Hawaii.

In drawing conclusions from the results presented here, we have assumed that differences in effectiveness of the various lures are insignificant and have not materially affected the catch rates. Lures were interchanged frequently so any effect produced by differential efficiency of lures should not be important. Variation in the number of lines fished during these cruises is likewise believed to have had such a minor effect on abundance figures that it is not considered. All vessels trolled either 5 or 6 lines, and it was a very rare occasion when all lines had simultaneous strikes.

The 1955-56 trolling results show variations of sufficient magnitude in certain aspects to warrant detailed examination, though overall catch rates for the period are low. Possible sources of variation are the time of day of fishing, seasonal change in catch rate, and the area of catch. On some cruises there is an indication of slightly higher catch rates in the morning than in the afternoon and early evening, but this is not consistent among cruises (fig. 8). The indication is of interest, however, since Reintjes and King (1953) found that yellowfin captured in the afternoon by trolling and live-bait fishing had more food in their stomachs and fewer empty stomachs than those captured in the morning. They conclude that feeding takes place throughout daylight hours. Bates (1950) found that troll catches of yellowfin did not vary significantly with time of day.

In respect to seasonal variation, yellowfin catch rates were highest in March and April (1.3 to 7.3 fish per hour) for all islands and generally low the rest of the year (usually < 2 fish per hour) as shown in figure 9. The July and August catch rates were extremely low (usually < 1 yellowfin per hour).

The data shown by cruises and trolling areas (fig. 10) demonstrate that generally yellowfin were more abundant at Palmyra and Kingman Reef (6°N.) than at Christmas (2°N.). Bates (1950) also reported this phenomenon. At present we have no explanation for this difference in abundance.

There are two important considerations from this analysis of our trolling data. First, the abundance of yellowfin in this area during the period studied was too low to encourage commercial exploitation of small tunas by this method of fishing. Second, there may be seasonal trends in abundance, for there were higher catches in March and April than during the remainder of the year. Table 2 contains a summary of trolling results for three different periods in the Line Islands area. Rather low catch rates were experienced during two of the time periods, i.e., October 1950 to April 1953 and March 1955 to February 1956. A slightly better catch rate was obtained during April to June 1950. The catch rate for this period, however, is not directly comparable with the other two, for fishing was confined to only a few months. Although only speculation, it seems that the abundance (judging by the troll catch rates) of the small yellowfin around the islands is too low to comprise the principal source of recruitment for the extensive population of large, deep-swimming yellowfin in this area.

Table 2.--Results of trolling in the Line Islands

Time	Hours trolled	Yellowfin	
		Number	Catch per hour
April to June 1950 (Bates 1950)	285.5	882	3.1
October 1950 to April 1953 (Murphy and Ikehara 1955)	178.0[1/]	241	1.4
March 1955 to February 1956	766.5	946	1.2

[1/] Murphy and Ikehara (1955) reported 890 line-hours of trolling using 4-6 lines. The number of hours trolled was obtained by dividing 890 line-hours by five, the average number of lines trolled.

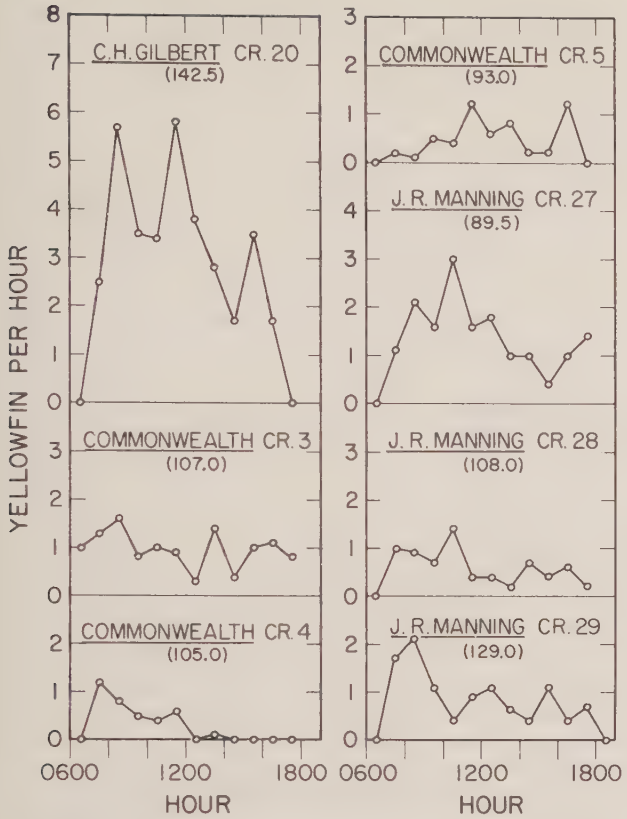

Figure 8.--Yellowfin troll catch rates in the Line Islands arranged by time of day (data in Appendix, table 6). The figures in the parentheses are the total number of hours trolled.

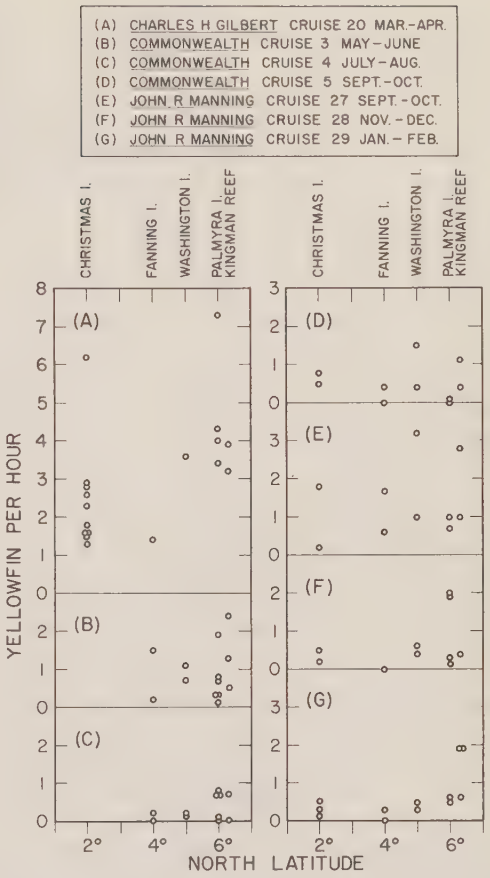
(A) CHARLES H GILBERT CRUISE 20 MAR.-APR.
(B) COMMONWEALTH CRUISE 3 MAY-JUNE
(C) COMMONWEALTH CRUISE 4 JULY-AUG.
(D) COMMONWEALTH CRUISE 5 SEPT.-OCT.
(E) JOHN R MANNING CRUISE 27 SEPT.-OCT.
(F) JOHN R MANNING CRUISE 28 NOV.-DEC.
(G) JOHN R MANNING CRUISE 29 JAN.-FEB.
CHRISTMAS I.
FANNING I.
WASHINGTON I.
PALMYRA I. KINGMAN REEF
YELLOWFIN PER HOUR
NORTH LATITUDE

Figure 10.--Relationship of yellowfin troll catch rates to areas, Line Islands, March 1955 to February 1956.

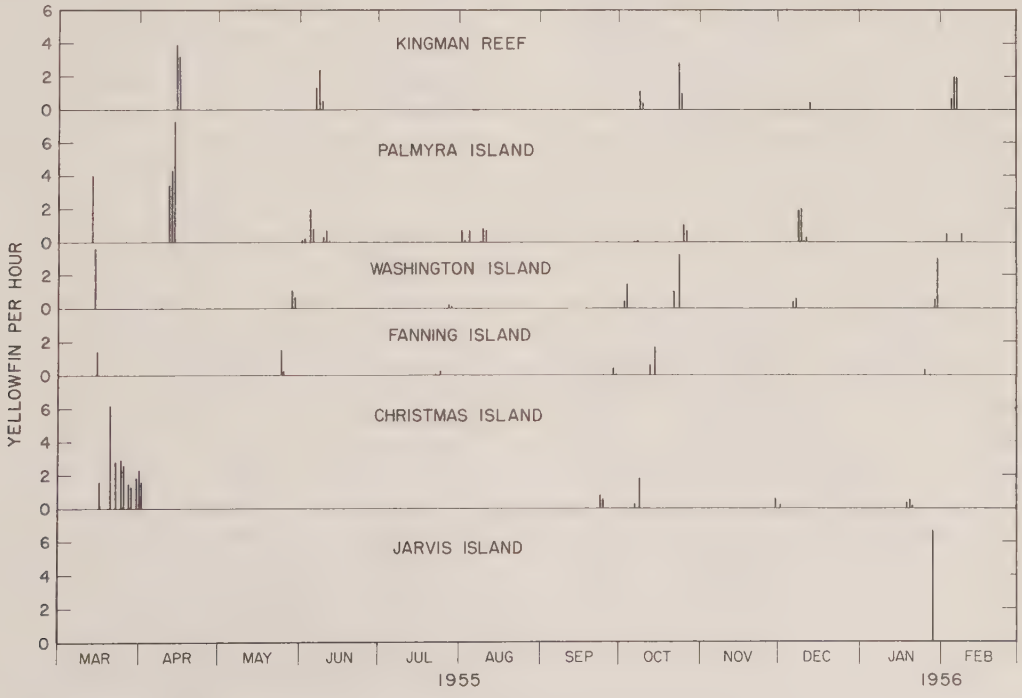

Figure 9.--Yellowfin troll catch rates in the Line Islands, March 1955 to February 1956.

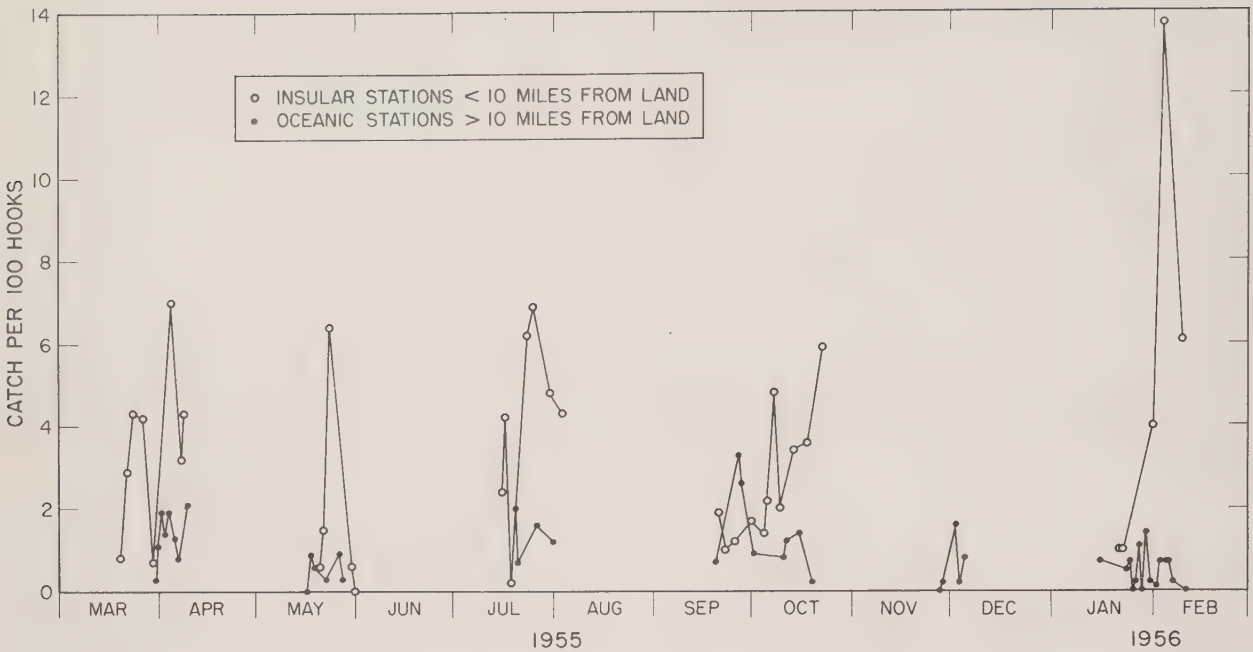

Figure 11.--Daily yellowfin longline catch rates in the Line Islands, 1955-56.

Longlining

The daily longline catch rates throughout the year for the Line Islands area are presented in figure 11. When two vessels fished on the same day an average rate is used. The longline catch rates at insular stations generally are higher than those at oceanic stations, which were consistently low during these cruises. The maximum catch rate for oceanic stations of 3.2 yellowfin per 100 hooks was made in September. For the remainder of the year catch rates were below 3 yellowfin per 100 hooks with the majority below 1 yellowfin per 100 hooks. Examination of the catch rates by latitude indicates no difference between areas.

The insular catch rates, on the other hand, show considerable variation throughout the year. Two possible sources of variation resulting from sampling procedure are: fishing at different seasons, and fishing in different areas. It is difficult to detect areal or temporal differences of significance in these data probably because of the large inherent variation in daily catch rates of longline gear in the vicinity of the islands (Iversen and Yoshida 1956); e.g., during cruise 20, Charles H. Gilbert, 6 stations were occupied within 10 miles of Christmas Island (between March 19 and April 5, Appendix, table 17) and the catch rates varied from 0.7 to 7.1 yellowfin per 100 hooks.

Japanese Longlining

Data are again available for the longline fishing operations of the Japanese in the vicinity of the Equator (Nomura 1955-56). This information is included in the Appendix, table 26. They report the best average catch rate of 5.29 yellowfin per 100 hooks during July at 2°-5°N., 160°-152°W. The poorest fishing (0.05 yellowfin per 100 hooks) was reported also during July but in an area a little to the north and west (5°-11°N., 178°-174°W). The average catch rate for the year was generally low.

TAGGING PROGRAM

At first consideration it would seem somewhat difficult to justify the expenditure of funds and effort to carry out a tagging program in the Line Islands, since the probability of recovery of tagged fish in this region is extremely low. Although occasionally Japanese vessels fish near the islands, there is not a steady and intensive fishery there. However, the potential value of such a program is high, since the recovery of only a few tags in this or other regions would contribute greatly to our knowledge of the migratory habits of yellowfin. Then too, tagging can be carried out in conjunction with fishing survey cruises which provide numbers of viable yellowfin in the process of determining abundance. The possibility of recovery of a few of these fish,

with the resulting information on their movements, greatly outweighs the information that can be gained by preserving or marketing them.

The specific purposes of the POFI equatorial tagging program were three. The first was to obtain information on the relationship between the small surface yellowfin (near islands) and the large, deep-swimming yellowfin (open ocean) and thus to investigate the possibility that recruitment into the larger size groups comes principally from the smaller size groups associated with islands. The extent of such recruitment from the surface schools around reefs into the longline fishery is of course a very important consideration. The second purpose was to examine the fluctuations in abundance of longline yellowfin from the standpoint of possible emigration. In other regions a few recoveries of tagged fish have done much to indicate the possible reasons for abundance changes; an outstanding example is the migration of albacore. A third purpose was to learn about the age and growth of yellowfin. The length of the fish is measured at the time of tagging and this also provides an estimate of its weight from the average length-weight relationship. As the fish is usually again measured or weighed on recovery, an estimate of gain in length or weight for a known period of time is thus obtained. With the accumulation of data it should be possible to calculate the average rate of growth and length of life of the species. Such information is especially desirable in this region, for a preliminary study of yellowfin vertebrae indicates that this structure is not suitable for age studies (Moore 1951); also size-frequency analyses indicate a lack of modal progression with time, preventing an estimate of growth (Iversen 1956).

In these studies we used the so-called "spaghetti" type of tag which has been described by Wilson (1953) and which has been used successfully to trace the migrations of albacore from California to Midway Island and Japan (Blunt 1954, Ganssle and Clemens 1953). Briefly, it consists of a white opaque plastic tube on which is written in India ink the tag number and directions for its return. For protection of the markings this tube is encased in a clear plastic tube of slightly larger diameter. The tag is threaded through the dorsal region of the fish just posterior to the second dorsal fin with a special hollow needle and the loose ends are tied by a figure-of-eight knot.

During nine cruises in 1955-56 1,056 yellowfin, 21 skipjack, 1 little tunny, and 2 bigeye were tagged and released. Table 3 lists the numbers of each species tagged and the tagging locations for both longlining and trolling. To date there have been two recoveries of tagged yellowfin, both from the same general locality in which they were captured and released. The first (No. 1093) was caught by trolling and was one of 2 fish tagged at Fanning Island on September 28, 1955. It was recaptured at Fanning Island by a local resident on April 3, 1956, using handline gear and fishing at a depth of about 50 fathoms. The fish had been at liberty for 188 days. At release it measured 83.2 cm. (estimated weight 25 lb.); at recovery it was reported to weigh 20 lb. The apparent shrinkage in weight is doubtless due to errors of estimate.

The second (No. 3351) was caught by trolling and was one of 16 tagged on October 8, 1955, at Christmas Island. It was recaptured at Christmas Island on August 2, 1956, by a local resident presumably by handline, and was

Table 3.--Numbers of tuna tagged in the Line Islands, March 1955 to February 1956

Area	Yellowfin	Skipjack	Bigeye	Little tunny
Trolling				
Kingman Reef	156	3	-	-
Palmyra I.	212	9	-	1
Washington I.	115	2	-	-
Fanning I.	41	6	-	-
Christmas I.	246	-	-	-
Jarvis I.	25	-	-	-
Longlining				
Line Islands (all areas)	261	1	2	-
Total	1,056	21	2	1

thus at liberty for 299 days. At release it measured 92 cm. (about 33 lb.); unfortunately on recovery it was cut up without being measured or weighed. The only estimate of size is that it was "about 3 feet long."

Considering the fact that over 1,000 yellowfin were tagged in 1955-56 and that, aside from the fishing of local residents, there has been a fair amount of fishing effort expended in the area by both POFI vessels and Japanese longliners, it is perhaps noteworthy that more tagged fish have not been recovered. This is particularly true for the small fish tagged close to the islands and presumed to be "local residents." The small number of recoveries could indicate that most of the small yellowfin are not year-round residents of the islands, but rather that they move about in the equatorial Pacific.

SUMMARY

1. This report reviews the general results of nine combination longlining and trolling cruises to the Line Islands between January 1955 and February 1956.

2. There is evidence to support previous findings that variation of longline catch rates among vessels fishing simultaneously in the same area is small.

3. The average depth reached by the deepest longline hooks varied about 40 fm. during these cruises. Near the Equator in the open ocean the deepest hooks usually did not fish as deep as they did at about 6°N. latitude or within 10 miles of the various islands.

4. The composition of the longline yellowfin catches did not differ greatly from past catches from the area; the ratio of males to females for all cruises averaged 2.26:1.00 and both oceanic and insular yellowfin size distributions had principal modes at the 140-149 cm. class interval, but the insular catches contained relatively more small fish.

5. The trolling catches of yellowfin in the Line Islands indicated that (1) the fish, with a mode at 70-79 cm., were generally smaller than those taken on longline, (2) the overall abundance was too low to recommend commercial exploitation by this method, (3) there was a seasonal trend in catch rates with the highest catch rates obtained in March-April and the lowest catch rates during May-September.

6. Higher troll catch rates of yellowfin were obtained more frequently at Palmyra and Kingman Reef to the north (6°N. latitude) than at Christmas Island (2°N. latitude) to the south.

7. Consistent with past experience the catch rates of longline yellowfin were higher close to islands than in the open ocean.

8. The longline catches in the open ocean were consistently low as compared with previous years, with the highest catch rates during September.

9. The insular longline catches demonstrated considerable variability that did not seem ascribable to seasonal or areal differences in fishing.

10. The Japanese longlining results in the equatorial region during 1955 also showed low catch rates.

11. A tagging program was carried out in conjunction with abundance studies during which 1,056 yellowfin, 21 skipjack, 1 little tunny, and 2 bigeye were tagged with plastic tube tags. As of September 1956, two tagged yellowfin have been recovered, both from the same area in which they were released.

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APPENDIX

Table 4.--List of common and scientific names of fishes used in this report

White-tipped shark, Pterolamiops longimanus (Poey)
Brown shark, Carcharhinus floridanus Bigelow, Schroeder and Springer
Great blue shark, Prionace glauca (Linnaeus)
Thresher shark, Alopias sp.
Bonito shark, Isurus glaucus Müller and Henle
Marlin, Makaira sp.
Sailfish, Istiophorus orientalis (Temminck and Schlegel)
Wahoo, Acanthocybium solandri (Cuvier and Valenciennes)
Dolphin, Coryphaena hippurus Linnaeus
Yellowfin tuna, Neothunnus macropterus (Temminck and Schlegel)
Bigeye tuna, Parathunnus sibi (Temminck and Schlegel)
Skipjack, Katsuwonus pelamis (Linnaeus)
Albacore, Germo alalunga (Bonnaterre)
Lancet fish, Alepisaurus sp.
Barracuda, Sphyraena barracuda (Walbaum)
Red snapper, Lutjanus bohar (Forskål)
Opah, Lampris sp.
Sunfish, Mola mola (Linnaeus)
Truncated sunfish, Ranzania truncata (Gmelin)
Broadbill swordfish, Xiphias gladius Linnaeus
Little tunny, Euthynnus affinis Cantor
Jack, Caranx sp.
Leatherjacket, Scomberoides sancti-petri (Cuvier)
Rainbow runner, Elagatis bipinnulatus (Quoy and Gaimard)
Needlefish, Belonidae
Puffer, Tetrodontidae

Table 5.--Length frequency distributions of oceanic and insular yellowfin caught by longlining and trolling in the Line Islands, January 1955 to February 1956

Length class	Troll	Longline	
		Oceanic	Insular
cm.			
40- 49	-	1	-
50- 59	7	1	1
60- 69	99	-	3
70- 79	277	4	6
80- 89	191	3	15
90- 99	150	6	16
100-109	118	5	46
110-119	69	13	48
120-129	43	36	83
130-139	8	51	89
140-149	3	76	101
150-159	1	66	97
160-169	-	4	19
Total	966	266	524

Table 6.--Yellowfin troll catch rates in the Line Islands arranged by time of day

Hour	Charles H. Gilbert Cruise 20			Commonwealth Cruise 3			Commonwealth Cruise 4			Commonwealth Cruise 5		
	Number of yellowfin	Hours trolled	Yellowfin per hour	Number of yellowfin	Hours trolled	Yellowfin per hour	Number of yellowfin	Hours trolled	Yellowfin per hour	Number of yellowfin	Hours trolled	Yellowfin per hour
0600-0700	-	1.0	-	2	2.1	1.0	-	0.8	-	-	0.7	-
0700-0800	7	2.8	2.5	10	7.7	1.3	6	4.8	1.2	2	8.2	0.2
0800-0900	33	5.8	5.7	18	11.0	1.6	6	7.0	0.8	1	10.0	0.1
0900-1000	21	6.0	3.5	9	11.0	0.8	4	7.5	0.5	5	10.0	0.5
1000-1100	23	6.8	3.4	11	11.0	1.0	3	8.0	0.4	4	10.0	0.4
1100-1200	41	7.0	5.8	10	11.0	0.9	4	6.8	0.6	12	10.0	1.2
1200-1300	23	6.0	3.8	4	12.1	0.3	-	7.0	-	6	10.0	0.6
1300-1400	17	6.0	2.8	14	10.3	1.4	1	7.0	0.1	7	9.3	0.8
1400-1500	9	5.2	1.7	3	8.5	0.4	-	6.5	-	2	8.8	0.2
1500-1600	14	4.0	3.5	7	7.0	1.0	-	5.0	-	2	8.0	0.2
1600-1700	5	2.9	1.7	8	7.0	1.1	-	3.2	-	6	4.8	1.2
1700-1800	-	1.0	-	4	4.7	0.8	-	1.0	-	-	1.4	-
1800-1900	-	-	-	-	-	-	-	-	-	-	-	-

Hour	John R. Manning Cruise 27			John R. Manning Cruise 28			John R. Manning Cruise 29			Charles H. Gilbert Cruise 25		
	Number of yellowfin	Hours trolled	Yellowfin per hour	Number of yellowfin	Hours trolled	Yellowfin per hour	Number of yellowfin	Hours trolled	Yellowfin per hour	Number of yellowfin	Hours trolled	Yellowfin per hour
0600-0700	-	2.1	-	-	2.3	-	-	1.0	-	-	-	-
0700-0800	7	6.1	1.1	7	7.1	1.0	12	7.2	1.7	-	-	-
0800-0900	18	8.7	2.1	8	8.8	0.9	22	10.3	2.1	12	0.7	17.1
0900-1000	14	9.0	1.6	7	10.0	0.7	12	11.0	1.1	16	1.0	16.0
1000-1100	24	8.0	3.0	14	10.0	1.4	5	11.0	0.4	8	1.0	8.0
1100-1200	15	9.2	1.6	4	10.0	0.4	10	11.0	0.9	6	1.0	6.0
1200-1300	18	10.2	1.8	4	10.0	0.4	12	11.0	1.1	-	1.0	-
1300-1400	10	10.0	1.0	2	10.0	0.2	7	11.0	0.6	-	0.8	-
1400-1500	9	8.4	1.1	7	10.0	0.7	5	11.0	0.4	-	-	-
1500-1600	3	7.1	0.4	4	10.0	0.4	12	11.0	1.1	-	-	-
1600-1700	5	5.2	1.0	5	8.0	0.6	4	11.0	0.4	-	-	-
1700-1800	2	1.4	1.4	1	5.6	0.2	7	9.9	0.7	-	-	-
1800-1900	-	-	-	-	-	-	-	0.6	-	-	-	-

Table 7.--Measurements of longline hook depth by chemical sounding tubes, 1955-56

Basket number	Hook number	Depth (fathoms)
Charles H. Gilbert Cruise 20		
Station 2		
7	5	77
18	4	42
30	5	63
42	6	43
54	6	44
Station 3		
7	5	52
18	5	44
31	6	47
42	7	44
54	5	55
Station 4		
8	5	75
18	5	70
30	4	80
42	6	55
54	6	53
Station 6		
8	6	Broken
19	7	50
30	3	55
48	6	55
54	5	45
Station 7		
6	6	57
18	6	48
30	7	55
42	6	44
54	6	49
Station 9		
7	6	65
18	6	62
30	6	70
42	5	65
54	6	73
Station 10		
6	7	55
18	7	60
31	6	67
42	6	60
54	6	63
Station 11		
6	6	72
18	6	46
30	6	58
42	6	48
53	5	Broken
Station 12		
6	6	60
18	6	57
30	7	60
42	7	65
54	7	77
Station 13		
56	2	44
56	4	62
56	6	71
56	8	66
56	10	100
Station 14		
54	7	58
54	7	58
54	7	59
54	7	58
54	7	59
Station 15		
56	2	54
56	4	74
56	8	74
56	10	50
John R. Manning Cruise 24		
Station 7		
15	6	54
27	6	34
30	5	59
31	5	32
34	6	34
45	6	73
Station 9		
15	9	57
27	6	58
31	7	> 100
33	6	62
35	6	58
45	6	68
Station 11		
15	6	59
27	6	50
30	6	60
31	5	54
34	5	51
45	6	42
Station 13		
15	6	75
27	5	65
30	2	26
32	5	58
34	6	55
45	6	61
Station 15		
10	6	68
15	6	92
20	6	70
40	6	72
45	6	67
50	6	72
Station 16		
16	6	67
27	6	54
32	6	52
35	6	55
50	6	63
Station 17		
10	6	78
15	6	82
20	6	65
40	6	80
45	6	80
50	6	78
Station 19		
15	10	57
15	8	75
15	6	92
45	10	40
45	8	54
45	6	57
Station 21		
1	6	> 100
4	7	> 100
56	6	71
60	6	95
Station 22		
15	6	87
Commonwealth Cruise 3		
Station 1		
1	6	54
6	6	50
10	6	52
20	6	65

Table 7.--Measurements of longline hook depth by chemical sounding tubes, 1955-56(Cont'd)

Basket number	Hook number	Depth (fathoms)
Commonwealth Cruise 3 (Cont'd)		
Station 2		
1	6	64
8	6	68
15	6	65
31	5	65
Station 3		
1	6	85
16	6	72
23	6	75
30	6	100
Station 4		
1	6	100
16	6	Broken
23	6	95
30	6	98
Station 5		
16	11	44
16	9	72
16	7	96
16	6	99
Station 6		
1	6	> 100
16	6	Broken
23	6	81
30	6	97
Station 7		
1	6	> 100
23	6	61
30	6	> 100
Station 8		
1	6	83
16	2	55
23	6	72
30	6	75
Station 9		
1	6	> 100
16	6	85
23	6	90
30	6	90
Station 10		
1	6	> 100
17	6	75
23	6	84
30	6	> 100
Station 11		
1	6	> 100
16	6	85
23	7	94
30	6	> 100
Commonwealth Cruise 4		
Station 1		
5	6	> 100
10	5	95
16	6	> 100
20	6	85
25	6	80
Station 2		
7	6	80
14	6	90
20	6	Lost
26	6	70
32	6	65
Station 3		
7	6	60
14	8	Broken
14	6	80
20	6	65
26	6	75
Station 4		
7	6	75
13	5	65
19	6	70
25	6	70
31	5	65
Station 5		
7	6	80
12	6	75
19	6	70
25	5	65
31	6	65
Station 6		
7	6	> 100
13	6	100
19	6	Lost
25	6	> 100
31	6	> 100
Station 7		
7	6	> 100
13	6	> 100
19	6	> 100
25	6	100
31	6	100
Station 8		
5	6	100
10	4	75
15	6	100
19	6	95
23	6	> 100
Station 9		
8	6	90
14	6	> 100
20	6	100
26	6	90
32	6	100
Station 10		
7	8	> 100
13	6	100
19	8	90
25	6	100
31	8	90
Station 11		
27	10	58
27	8	Lost
27	6	90
27	4	67
27	2	50
Commonwealth Cruise 5		
Station 1		
1	6	67
10	7	78
20	6	60
Station 2		
21	9	36
21	6	72
30	6	42
40	6	89
Station 3		
1	7	71
21	6	59
39	6	88
Station 5		
21	6	36
38	5	73
40	6	95

Table 7.--Measurements of longline hook depth by chemical sounding tubes, 1955-56 (Cont'd)

Basket number	Hook number	Depth (fathoms)
Commonwealth Cruise 5 (Cont'd)		
Station 6		
1	6	90
21	7	90
39	7	93
40	7	92
Station 8		
38	6	65
39	6	70
40	6	88
Station 9		
21	6	44
37	6	44
38	6	Broken
40	6	60
Station 10		
21	6	80
37	6	72
38	6	67
40	6	> 100
Station 11		
38	6	58
39	6	65
40	6	85
John R. Manning Cruise 27		
Station 1		
6	6	-
18	6	55
31	6	60
42	6	57
54	6	50
Station 2		
6	6	57
18	6	55
31	6	50
42	6	50
54	6	54
Station 3		
6	6	63
18	6	> 100
31	6	77
43	6	70
54	6	70
Station 5		
6	6	82
18	6	80
31	5	77
42	6	77
55	6	80
Station 6		
6	6	87
18	6	85
31	6	82
42	6	85
54	6	75
Station 7		
6	6	81
18	5	69
31	6	73
42	6	63
54	6	72
Station 8		
6	6	100
18	6	75
31	6	59
42	6	Lost
54	6	64
Station 9		
6	6	Lost
18	6	74
31	6	80
42	6	77
54	6	77
Station 10		
6	6	-
18	Basket lost	
31	6	> 100
42	6	> 100
54	6	91
Station 11		
6	6	75
18	6	75
31	6	82
40	6	86
52	4	83
Station 12		
6	6	84
18	6	89
28	6	> 100
40	6	94
52	5	91
John R. Manning Cruise 28		
Station 1		
10	5	55
20	6	-
30	6	-
40	6	-
50	6	55
Station 2		
10	6	68
20	5	72
30	6	68
41	6	55
50	6	63
Station 5		
10	5	42
20	6	52
30	5	58
40	-	-
50	5	63
Station 7		
11	6	-
31	6	37
51	6	37
71	6	42
91	5	53
Station 8		
11	6	-
31	6	42
51	4	38
72	6	38
91	6	51
Charles H. Gilbert Cruise 25		
Station 2		
7	5	46
15	5	52
25	3	44
26	5	47
35	5	50
Station 3		
5	6	52
15	6	51
16	5	-
25	6	52
35	6	61
Station 4		
21	5	70
37	6	74
38	6	100
39	6	76
40	6	84
Station 5		
21	6	95
37	6	99
38	6	96
39	5	91
40	6	> 100

Table 7.--Measurements of longline hook depth by chemical sounding tubes, 1955-56 (Cont'd)

Basket number	Hook number	Depth (fathoms)
Charles H. Gilbert Cruise 25 (Cont'd)		
Station 6		
5	6	91
13	6	89
24	6	96
25	6	98
35	6	90
Station 7		
5	6	91
15	6	95
25	11	45
25	9	80
25	7	100
25	6	95
35	6	90
Station 8		
5	6	84
10	6	80
15	6	89
21	6	96
25	6	95
33	6	94
Station 9		
5	6	85
10	6	79
16	6	85
22	6	81
28	6	84
34	6	84
Station 10		
5	6	80
23	10	60
23	8	76
23	4	61
23	2	44
35	6	85
Station 11		
5	6	91
11	6	86
17	6	98
23	6	85
29	6	89
35	6	79

Basket number	Hook number	Depth (fathoms)
John R. Manning Cruise 29		
Station 8		
5	6	44
12	5	41
22	5	34
31	6	40
42	6	57
52	6	80
Station 10		
5	6	70
15	6	100
25	4	40
35	6	39
45	6	46
55	5	68
Station 11		
5	5	Broken
15	6	46
25	6	60
35	7	70
45	6	65
55	6	72
Station 12		
5	6	58
15	6	> 100
25	6	45
35	7	72
45	6	75
55	6	75
Station 13		
5	6	75
15	6	43
25	6	47
35	6	62
45	6	53
55	6	64
Station 14		
10	6	> 100
20	6	> 100
31	4	85
40	6	70
50	6	60

Basket number	Hook number	Depth (fathoms)
Station 15		
10	6	55
20	6	-
30	4	65
40	6	65
50	5	65
Station 16		
10	6	53
20	6	55
31	7	67
40	6	69
50	6	-
Station 17		
10	6	62
20	6	63
30	7	70
41	5	75
50	6	60
Station 18		
10	6	95
20	6	75
30	5	80
41	5	78
50	6	74
Station 21		
16	6	56
30	6	56
46	6	42
Station 22		
15	6	58
30	6	65
45	6	71

Table 8.--Summary of direct trolling, Charles H. Gilbert cruise 19

Date 1955	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
1/30	20 mi. NW of Kingman Reef	11.5	3	7	-	-	0.3
2/2	Palmyra I.	10.5	5	5	11	2 dolphin 1 barracuda 1 rainbow runner	0.5
2/3	Washington I.	11.0	2	1	-	-	0.2
2/4	Fanning I.	3.0	-	-	-	-	-
2/5	Fanning I.	4.0	-	2	-	-	-
2/6	Fanning I.	5.5	-	-	-	-	-
2/8	Christmas I.	7.5	-	-	-	-	-
2/9	Christmas I.	3.0	3	-	-	-	1.0
2/11	Washington I.	12.5[2/]	21	1	2	2 dolphin	1.7
Total		68.5	34	16	13		

[1/] 2-5 lines fished at all times
[2/] Includes approximately 5.5 hours of running from Fanning I. to Washington I.

Table 9.--Summary of direct trolling, Charles H. Gilbert cruise 20

Date 1955	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
3/13	Palmyra I.	7.5	30	1	17	2 red snapper, 2 barracuda, 1 little tunny, 6 rainbow runner	4.0
3/14	Washington I.	7.0	25	2	4	3 barracuda, 1 rainbow runner	3.6
3/15	Fanning I.	5.0	7	-	2	-	1.4
3/16	Christmas I.	2.5	4	-	8	1 rainbow runner, 2 leatherjacket	1.6
3/20	Christmas I.	8.5	53	-	15	1 jack, 1 barracuda	6.2
3/22	Christmas I.	4.0	11	-	9	-	2.8
3/24	Christmas I.	9.0	26	-	17	2 jack, 1 rainbow runner	2.9
3/25	Christmas I.	11.0	29	-	16	1 barracuda, 1 brown shark	2.6
3/27	Christmas I.	10.0	15	-	30	1 jack	1.5
3/28	Christmas I.	11.5	15	-	26	1 brown shark	1.3
3/30	Christmas I.	12.0	22	-	18	3 jack	1.8
3/31	Christmas I.	9.5	22	-	27	2 rainbow runner, 3 jack	2.3
4/1	Christmas I.	11.0	18	-	33	1 barracuda, 4 rainbow runner	1.6
4/11	Palmyra I.	5.0	17	1	8	2 rainbow runner, 2 barracuda	3.4
4/12	Palmyra I.	6.5	28	-	5	2 rainbow runner	4.3
4/13	Palmyra I.	8.5	62	5	17	3 rainbow runner, 1 barracuda, 1 brown shark	7.3
4/14	Kingman Reef	8.5	33	-	12	1 rainbow runner, 1 brown shark, 3 red snapper	3.9
4/15	Kingman Reef	6.5	21	1	10	-	3.2
	Total	143.5	438	10	274		

[1/] 5 lines fished at all times

Table 10.--Summary of direct trolling, Commonwealth cruise 3

Date 1955	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
5/24	Fanning I.	6.5	10	-	-	-	1.5
5/25	Fanning I.	10.5	2	-	16	-	0.2
5/28	Washington I.	7.0	8	-	9	1 barracuda	1.1
5/29	Washington I.	5.5	4	-	8	1 rainbow runner	0.7
6/1	Palmyra I.	9.0	1	-	6	1 jack	0.1
6/2	Palmyra I.	9.0	3	-	3	3 jack	0.3
6/4	Palmyra I.	10.5	20	-	21	1 jack	1.9
6/5	Palmyra I.	10.5	8	-	19	1 barracuda, 1 jack, 1 rainbow runner	0.8
6/6	Kingman Reef	6.0	8	-	4	2 red snapper, 1 jack, 1 rainbow runner	1.3
6/7	Kingman Reef	10.0	24	-	35	3 jack, 1 red snapper	2.4
6/8	Kingman Reef	10.0	5	-	3	1 barracuda, 4 jack, 2 red snapper	0.5
6/9	Palmyra I.	6.0	2	-	1	1 jack	0.3
6/10	Palmyra I.	7.0	5	-	10	1 jack	0.7
	Total	107.5	100	-	135		

[1/] 6 lines fished at all times

Table 11.--Summary of direct trolling, Commonwealth cruise 4

Date 1955	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
7/22	Fanning I.	10.5	-	-	1	-	-
7/24	Fanning I.	10.0	2	-	11	4 jack 4 brown shark, 1 red snapper	0.2
7/27	Washington I.	11.0	2	-	20	1 jack, 1 brown shark	0.2
7/28	Washington I.	9.5	1	-	6	-	0.1
8/1	Palmyra I.	7.0	5	-	6	1 jack	0.7
8/2	Palmyra I.	10.0	1	-	5	1 jack	0.1
8/4	Palmyra I.	7.0	5	-	14	-	0.7
8/5	Kingman Reef	5.5	-	-	2	1 brown shark, 2 barracuda	-
8/6	Kingman Reef	11.0	-	-	6	1 brown shark, 2 red snapper, 1 little tunny	-
8/7	Kingman Reef	4.0	-	-	-	2 red snapper	-
8/7	Palmyra I.	2.5	-	-	-	-	-
8/8	Palmyra I.	4.5	-	-	4	2 brown shark	-
8/9	Palmyra I.	3.5	3	-	4	2 brown shark	0.8
8/10	Kingman Reef	7.5	5	-	4	2 red snapper	0.7
	Total	103.5	24	-	83		

[1/] 6 lines fished at all times

Table 12.--Summary of direct trolling, Commonwealth cruise 5

Date 1955	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
9/23	Christmas I.	10.5	9	-	5	-	0.8
9/24	Christmas I.	9.5	5	-	12	-	0.5
9/28	Fanning I.	7.5	3	-	2	-	0.4
9/29	Fanning I.	9.0	-	-	7	-	-
10/2	Washington I.	9.5	4	-	3	-	0.4
10/3	Washington I.	8.5	13	-	16	-	1.5
10/6	Palmyra I.	6.5	-	-	2	-	-
10/7	Palmyra I.	10.5	1	-	15	1 jack	0.1
10/8	Kingman Reef	5.5	6[2/]	-	6	-	1.1
10/9	Kingman Reef	11.0	5	-	4	-	0.4
	Total	88.0	46	-	72		

[1/] 6 lines fished at all times

[2/] 1 yellowfin shark-bitten

Table 13.--Summary of direct trolling, John R. Manning cruise 27

Date 1955	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
10/6	Christmas I.	6.5	1	-	27	5 jack	0.2
10/8	Christmas I.	10.0	18	-	19	5 jack	1.8
10/12	Fanning I.	9.0	5	1	15	1 rainbow runner	0.6
10/14	Fanning I.	9.5	16	5	10	3 jack, 2 rainbow runner, 1 red snapper	1.7
10/16	Washington I.	10.0	10	-	9	3 rainbow runner	1.0
10/18	Washington I.	9.0	29	-	1	-	3.2
10/20	Palmyra I.	7.0	7	1	8	2 rainbow runner	1.0
10/21	Palmyra I.	9.0	6	2	16	1 needlefish	0.7
10/23	Kingman Reef	8.5	24	-	46	7 rainbow runner	2.8
10/24	Kingman Reef	8.5	9	-	22	1 rainbow runner, 1 needlefish, 1 dolphin	1.0
	Total	87.0	125	9	173		

[1/] 6 lines fished at all times

Table 14.--Summary of direct trolling, John R. Manning cruise 28

Date 1955	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
11/30	Christmas I.	11.0	6	-	32	1 rainbow runner	0.5
12/1	Christmas I.	11.0	2	-	15	-	0.2
12/4	Fanning I.	10.5	0	-	14	-	-
12/6	Washington I.	11.0	4	-	53	4 rainbow runner	0.4
12/7	Washington I.	12.0	7	1	2	-	0.6
12/8	Palmyra I.	9.5	18	-	8	1 rainbow runner, 1 jack	1.9
12/9	Palmyra I.	8.5	17	-	2	1 rainbow runner	2.0
12/10	Palmyra I.	8.0	1	-	7	-	0.1
12/11	Palmyra I.	9.0	3	-	4	1 rainbow runner, 1 barracuda	0.3
12/12	Kingman Reef	12.0	5	-	6	-	0.4
Total		102.5	63	1	143		

[1/] 6 lines fished at all times

Table 15.--Summary of direct trolling, Charles H. Gilbert cruise 25

Date 1956	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
1/28	Jarvis I.	5.5	42	-	7	34 jack, 2 rainbow runner, 2 brown shark, 1 red snapper	7.6

[1/] 6 lines fished

Table 16.--Summary of direct trolling, John R. Manning cruise 29

Date 1956	Area	Hours trolled[1/]	Catch				Yellowfin/ hour
			Yellowfin	Skipjack	Wahoo	Others	
1/18	Christmas I.	11.5	4	-	22	-	0.3
1/19	Christmas I.	11.5	6	-	12	-	0.5
1/20	Christmas I.	11.5	1	-	14	-	0.1
1/25	Fanning I.	11.0	3	-	11	-	0.3
1/27	Fanning I.	11.0	-	4[2/]	7	-	-
1/29	Washington I.	11.0	6	-	40	-	0.5
1/30	Washington I.	10.0	30	-	48	4 rainbow runner	3.0
2/2	Palmyra I.	11.0	6	-	36	4 rainbow runner	0.5
2/4	Kingman Reef	10.0	6	-	17	1 rainbow runner	0.6
2/5	Kingman Reef	10.5	20	2	9	1 barracuda, 2 rainbow runner	1.9
2/6	Kingman Reef	10.5	20	1	17	2 rainbow runner	1.9
2/8	Palmyra I.	9.5	6	-	27	-	0.6
Total		129.0	108	7	260		

[1/] 6 lines fished at all times

[2/] Includes 1 skipjack which jumped on deck

Table 17.--Summary of longline catches, Charles H. Gilbert cruise 20

Date 1955	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
3/19	02°00.8'N.	157°51'W.	2	60	658	5	14	1 marlin	0.8
3/21	02°38'N.	157°57'W.	3	60	655	19(2)[1/]	17	1 wahoo, 1 marlin, 1 bigeye	2.9
3/23	01°52'N.	157°42'W.	4	60	654	28(7)	16	-	4.3
3/26	01°55'N.	157°47'W.	6	60	642	27(6)	12	1 sailfish	4.2
3/29	01°58'N.	157°34'W.	7	60	557	4(1)	16	1 lancet fish, 1 marlin	0.7
4/2	02°01'N.	157°04'W.	9	60	656	17(6)	12	1 marlin	2.6
4/3	01°35'N.	156°46'W.	10	60	651	14(2)	7	1 skipjack, 1 lancet fish	2.2
4/4	01°52'N.	157°45'W.	11	60	647	46(3)	7	1 dolphin	7.1
4/5	02°12'N.	157°22'W.	12	60	656	9(2)	16	1 skipjack	1.4
4/6	03°00'N.	158°28'W.	13	60	658	6	3	1 marlin	0.9
4/7	03°51'N.	159°33'W.	14	60	655	22(7)	29	-	3.4
4/8	04°31'N.	160°30'W.	15	60	656	35(5)	23	1 marlin	5.3
4/9[2/]	05°12'N.	161°41'W.	16	60	657	14(5)	10	1 sunfish, 1 skipjack 1 marlin	2.1
Total				780	8,402	246(46)	182		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

[2/] The Charles H. Gilbert spent part of April 9 and 10 to haul gear set by the John R. Manning. Two yellowfin and 5 sharks were caught on the cotton gear and 8 sharks were caught on the steel gear.

Table 18.--Summary of longline catches, John R. Manning cruise 24

Date 1955	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
				Cotton Gear					
3/30	05°49.5'N.	154°58'W.	7	30	327	2	3	1 bigeye	0.6
3/31	04°19'N.	154°50'W.	9	30	327	3	5	-	0.9
4/1	02°35'N.	155°08'W.	11	30	326	7	7	-	2.1
4/2	01°20'N.	155°09'W.	13	30	327	2(2)[1]	7	1 bigeye, 1 broadbill	0.6
4/3	01°48.5'N.	156°40'W.	15	30	326	4	7	2 marlin	1.2
4/4	01°49'N.	157°38'W.	16	29	316	19(2)	6	2 marlin	6.0
4/5	02°32'N.	157°19'W.	17	30	327	3	3	1 skipjack, 1 marlin	0.9
4/6	02°57'N.	158°32'W.	19	30	323	5	4	1 bigeye 2 wahoo	1.5
4/7	03°44.5'N.	159°29'W.	21	30	325	10(2)	16	-	3.1
4/8	04°42'N.	160°36'W.	22	30	325	18(7)	18	1 marlin	5.5
4/9[2]	05°09.5'N.	161°31'W.	24	30	-	-	-	-	-
Total				329	3,249	73(13)	76		
				Steel Gear					
3/30	05°49.5'N.	154°58'W.	7	30	298	-	5	1 lancet fish	-
3/21	04°19'N.	154°50'W.	9	30	306	4	3	1 lancet fish	1.3
4/1	02°35'N.	155°08'W.	11	30	300	5(1)	4	1 wahoo, 2 sunfish	1.7
4/2	01°20'N.	155°09'W.	13	30	312	-	5	1 broadbill	-
4/3	01°48.5'N.	156°40'W.	15	30	308	6(1)	7	1 skipjack	1.9
4/4	01°49'N.	157°38'W.	16	29	308	23(4)	2	-	7.5
4/5	02°32'N.	157°19'W.	17	29	310	5	4	1 marlin	1.6
4/6	02°57'N.	158°32'W.	19	31	327	-	4	1 marlin	-
4/7	03°44.5'N.	159°29'W.	21	31	327	9(1)	16	1 bigeye	2.8
4/8	04°42'N.	160°36'W.	22	31	318	3	5	1 marlin	0.9
4/9[2]	05°09.5'N.	161°31'W.	24	30	-	-	-	-	-
Total				331	3,114	55(7)	55		

[1] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

[2] Gear hauled by the Charles H. Gilbert

Table 19.--Summary of longline catches, Commonwealth cruise 3

Date 1955	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
5/16	00°20'N.	156°52'W.	1	20	215	-	-	-	-
5/17	01°21'N.	157°22'W.	2	31	340	3(1)[1/]	3	-	0.9
5/18	02°05'N.	156°58'W.	3	30	329	2(1)	-	-	0.6
5/20	01°59'N.	157°39'W.	4	30	327	2(1)	6	1 marlin	0.6
5/21	02°05'N.	157°35'W.	5	30	329	5(3)	20	-	1.5
5/22	03°29'N.	158°52'W.	6	30	327	1	9	1 lancet fish	0.3
5/23	03°43'N.	159°23'W.	7	30	328	21(6)	5	-	6.4
5/26	04°13'N.	159°48'W.	8	30	330	3	-	1 bigeye, 2 skipjack	0.9
5/27	04°41'N.	160°11'W.	9	30	330	1	3	1 marlin	0.3
5/30	05°15'N.	161°10'W.	10	30	330	2(1)	3	2 bigeye, 1 lancet fish	0.6
5/31	05°44'N.	162°03'W.	11	30	330	-	4	3 bigeye, 1 marlin	-
Total				321	3,515	40(13)	53		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

Table 20.--Summary of longline catches, Commonwealth cruise 4

Date 1955	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
7/15	01°54'N.	157°41'W.	1	30	326	8(2)[1/]	2	-	2.4
7/16	01°50.5'N.	157°39'W.	2	37	406	17	4	1 marlin	4.2
7/18	01°52'N.	157°43'W.	3	37	407	1	6	-	0.2
7/19	02°24'N.	157°42'W.	4	37	404	8	7	-	2.0
7/20	03°08'N.	158°48'W.	5	37	407	3(2)	7	1 bigeye, 3 skipjack, 1 puffer	0.7
7/23	03°52'N.	159°34'W.	6	37	403	25(5)	16	-	6.2
7/25	04°03'N.	159°39'W.	7	37	403	28(8)	24	1 skipjack, 1 bigeye, 2 marlin	6.9
7/26	04°24'N.	159°57'W.	8	28	308	5	8	1 bigeye	1.6
7/30	04°48'N.	160°37'W.	9	37	398	19(7)	9	2 marlin	4.8
7/31	05°22'N.	161°07'W.	10	37	406	5	1	1 bigeye	1.2
8/3	05°47'N.	161°56'W.	11	36	395	17(8)	10	-	4.3
8/8	Anchored reef Palmyra I.		14 (special)	3[2/]	29	1(1)	20	-	3.4
Total				390	4,292	137(33)	114		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

[2/] Not counted in totaling baskets

Table 21.--Summary of longline catches, Commonwealth cruise 5

Date 1955	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
9/19	00°29'N.	157°53'W.	1	40	412	3(1)[1/]	3	2 dolphin	0.7
9/20	01°38'N.	157°49'W.	2	40	416	8	2	-	1.9
9/22	02°01'N.	157°46'W.	3	39	393	4(1)	6	1 wahoo, 1 marlin	1.0
9/25	02°09'N.	157°45'W.	4	40	413	5(1)	3	1 marlin	1.2
9/26	02°32'N.	157°52'W.	5	40	423	14(1)	8	2 skipjack	3.3
9/27	02°59'N.	158°31'W.	6	40	418	11(1)	5	1 sailfish, 1 skipjack	2.6
9/30	03°56'N.	159°36'W.	8	40	420	7(4)	11	1 bigeye, 1 marlin	1.7
10/1	04°20'N.	160°06'W.	9	40	433	4	5	1 skipjack	0.9
10/4	04°47'N.	160°43'W.	10	40	433	8(2)	21	1 marlin	1.8
10/5	06°03'N.	162°06'W.	11	40	425	14(2)	7	-	3.3
Total				399	4,186	78(13)	71		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

Table 22.--Summary of longline catches, John R. Manning cruise 27

Date 1955	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
10/4	00°28.5'N.	157°48.5'W.	1	60	650	7(2)[1/]	6	-	1.1
10/5	01°25'N.	158°14'W.	2	60	649	8(5)	7	1 lancet fish, 1 puffer	1.2
10/7	02°03.5'N.	157°33'W.	3	60	646	31(11)	13	-	4.8
10/9	02°14'N.	157°59'W.	5	60	653	13(2)	4	1 marlin, 1 bigeye	2.0
10/10	02°45'N.	158°05.5'W.	6	60	652	5(1)	2	1 marlin, 3 bigeye, 1 wahoo	0.8
10/11	03°17'N.	158°37.5'W.	7	60	645	8(1)	7	-	1.2
10/13	03°56.5'N.	159°40.5'W.	8	60	648	22(14)	26	-	3.4
10/15	04°22'N.	160°06'W.	9	60	648	9(1)	10	1 lancet fish, 1 bigeye, 2 skipjack, 5 dolphin	1.4
10/17	04°40.5'N.	160°27'W.	10	47	500	18(16)	57	-	3.6
10/19	05°34.5'N.	160°54'W.	11	57	620	1	5	1 marlin	0.2
10/22	05°49.5'N.	161°57'W.	12	57	609	36(10)	18	-	5.9
Total				641	6,920	158(63)	155		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

Table 23.--Summary of longline catches, John R. Manning cruise 28

Date 1955	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
11/27	01°14'N.	157°25'W.	1	60	617	-	13	1 marlin	-
11/28	01°58.5'N.	157°58'W.	2	60	632	1(1)[1/]	11	-	0.2
12/2	02°24'N.	157°48'W.	5	60	635	10(2)	10	2 skipjack, 2 dolphin, 1 broadbill, 1 lancet fish	1.6
12/3	02°58.5'N.	158°50'W.	7	99	1,040	2	16	1 skipjack, 1 wahoo, 1 dolphin	0.2
12/5	04°05.5'N.	159°48.5'W.	8	99	1,022	8(2)	23	1 wahoo, 1 lancet fish	0.8
Total				378	3,946	21(5)	73		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

Table 24.--Summary of longline catches, Charles H. Gilbert cruise 25

Date 1956	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
1/25	03°39'N.	160°04'W.	2	40	433	-	1	1 wahoo	-
1/26	01°22.5'N.	160°17'W.	3	40	427	1	1	1 marlin	0.2
1/27	00°12.5'S.	160°24'W.	4	40	435	5	2	1 skipjack	1.1
1/29	01°26.5'S.	160°16'W.	5	40	428	6(1)[1/]	4	2 skipjack, 1 wahoo	1.4
1/30	03°43'S.	159°59'W.	6	40	434	1	1	-	0.2
2/1	04°34'S.	166°03'W.	7	40	428	-	6	1 marlin	-
2/2	03°09.5'S.	168°24'W.	8	40	430	3	5	1 bigeye, 1 barracuda	0.7
2/4	00°07'N.	167°14'W.	9	40	433	3	6	1 marlin	0.7
2/5	02°37.5'N.	166°12.5'W.	10	40	433	3(1)	5	1 skipjack	0.7
2/6	03°55'N.	164°34'W.	11	40	432	1	6	1 wahoo, 1 skipjack, 3 lancet fish	0.2
Total				400	4,313	23(2)	37		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

Table 25.--Summary of longline catches, John R. Manning cruise 29

Date 1956	Noon position		Station	Number of baskets	Number of hooks	Catch			Yellowfin/ 100 hooks
	Latitude	Longitude				Yellowfin	Shark	Others	
1/15	01°06.5'N.	157°21'W.	8	56	583	4	8	2 skipjack	0.7
1/21	01°54.5'N.	157°48'W.	10	60	595	6(3)[1/]	6	-	1.0
1/22	02°20'N.	157°47'W.	11	60	614	6	8	2 skipjack	1.0
1/23	02°52.5'N.	158°30.5'W.	12	60	608	3(1)	15	1 bigeye, 1 skipjack, 1 marlin	0.5
1/24	03°23.6'N.	158°45'W.	13	60	598	4(2)	16	1 wahoo	0.7
1/26	03°49.5'N.	159°37.5'W.	14	60	610	2	10	1 bigeye	0.3
1/28	04°27.5'N.	160°11'W.	15	60	616	-	15	1 skipjack, 1 marlin, 1 wahoo	-
1/31	04°46'N.	160°37'W.	16	60	575	23(15)	45	1 skipjack	4.0
2/1	05°33'N.	161°31'W.	17	60	612	1	8	2 marlin, 2 lancet fish	0.2
2/3	05°52'N.	162°20'W.	18	60	604	83(34)	71	1 bigeye, 1 wahoo	13.7
2/9	05°58'N.	162°18'W.	21	60	607	37(11)	18	1 bigeye, 3 marlin, 1 barracuda	6.1
2/10	07°30'N.	161°44.5'W.	22	60	619	-	2	5 bigeye, 2 marlin, 3 dolphin	-
Total				716	7,241	169(66)	222		

[1/] Numbers in parentheses are shark-damaged fish and are included in the adjacent daily catch

Table 26.--Japanese commercial longline fishing in the central Pacific during 1955 (data from Nomura 1955-56)

Area	Stations	Boats	Baskets	Hooks	Average catch per 100 hooks									
					Yellowfin	Bigeye	Albacore	Skipjack	Black marlin	White marlin	Broadbill	Sailfish	Shark	Miscella-neous
							January							
6°-7°N. 127°-124°W.	32	1	11,320	56,600	1.33	3.92	-	-	0.23	0.02	0.03	-	-	-
29°-33°N. 179°E.-158°W.	216	10	67,326	326,128	0.01	2.74	1.13	0.02	-	-	0.16	-	0.23	0.03
27°-32°N. 180°-165°W.	109	5	39,007	189,055	0.03	2.48	0.18	0.01	-	-	0.10	-	0.20	0.03
6°-12°N. 180°-156°W.	81	4	30,213	128,910	0.17	2.36	-	-	0.21	0.01	0.01	0.01	0.20	0.01
13°-14°S. 180°-177°W.	9	1	3,420	13,680	0.85	-	2.60	0.10	0.25	-	-	-	-	0.05
14°-24°S. 178°-169°W.	65	3	24,270	112,550	1.20	0.05	2.63	0.01	0.65	0.01	-	0.01	-	0.16
2°S.-12°N. 129°-158°E.	84	7	22,742	109,707	1.16	1.39	0.01	0.07	0.16	0.01	0.03	0.04	0.01	0.08
2°-17°S. 143°-168°E.	374	14 (2)	140,881	632,971	2.64	0.15	1.18	-	0.38	0.06	0.01	0.19	0.04	0.07
13°-29°S. 146°-169°E.	217	7	93,822	390,278	2.38	0.17	1.12	-	0.32	0.20	0.02	0.64	0.01	0.18
34°-37°N. 161°-169°E.	14	1	3,480	20,880	-	0.24	2.63	-	-	-	0.53	-	1.73	0.03
29°-37°N. 149°-180°E.	655	33	159,862	979,195	0.01	0.60	3.75	-	-	-	0.19	-	0.45	0.03
28°-36°N. 139°-151°E.	578	39	94,635	685,550	0.03	0.34	2.84	0.02	-	-	0.20	-	0.63	0.01
19°-32°N. 130°-158°E.	441	25	95,105	658,185	0.12	0.21	1.58	0.02	-	-	0.06	-	0.17	0.04
							February							
11°-15°S. 146°-143°W.	32	1	12,986	65,930	1.27	0.15	2.19	-	1.99	0.03	0.01	0.02	-	-
28°-33°N. 159°-154°W.	92	4	27,987	133,608	0.01	3.54	0.35	-	-	-	0.15	-	0.01	0.08
28°-31°N. 174°-162°W.	24	1	8,963	44,815	-	2.30	0.25	-	-	-	0.12	-	0.12	0.03
5°-12°N. 178°E.-173°W.	233	12	81,998	393,355	0.34	3.02	0.02	0.01	0.19	0.01	0.01	0.01	0.15	0.11
12°-16°S. 179°-169°W.	57	3	21,660	93,120	1.79	0.05	2.57	-	0.87	0.01	-	0.02	-	0.09
14°-20°S. 179°-169°W.	75	4	28,833	122,902	2.85	0.07	2.01	-	0.82	0.01	-	0.08	-	0.22
10°-11°N. 166°-167°E.	17	1	6,460	32,300	0.14	2.73	-	0.03	0.32	0.01	0.04	-	-	0.64
9°-13°N. 174°-180°E.	44	2	15,440	77,200	0.24	2.84	0.01	0.02	0.22	0.01	0.03	0.01	-	0.20
2°S.-11°N. 129°-158°E.	208	13	68,020	324,146	2.15	0.72	-	0.04	0.28	0.01	0.01	0.08	0.04	0.02
1°-10°N. 171°-176°E.	72	4	24,586	120,680	1.40	1.72	0.01	-	0.41	0.01	-	-	-	0.12
2°N.-16°S. 131°-175°E.	375	16	139,468	635,310	2.37	0.37	0.83	0.02	0.41	0.07	0.01	0.07	0.08	0.09
15°-18°S. 160°-178°E.	88	3	34,688	145,610	3.14	0.09	1.39	-	0.60	0.02	-	0.05	0.14	0.10
29°-36°N. 153°E.-175°W.	350	18	80,999	500,713	0.01	0.43	2.67	-	-	-	0.26	-	0.40	0.01
28°-36°N. 139°-153°E.	570	32	95,668	686,557	0.03	0.26	3.31	0.02	-	-	0.12	-	0.43	0.01
28°-35°N. 137°-141°E.	10	1	1,584	11,088	0.05	0.20	3.45	0.01	-	-	0.05	-	0.22	-
27°-33°N. 131°-141°E.	291	16	57,378	385,777	0.04	0.17	2.57	0.01	-	-	0.05	-	0.17	0.01

Table 26.--Japanese commercial longline fishing in the central Pacific during 1955 (data from Nomura 1955-56) (Cont'd)

Area	Stations	Boats	Baskets	Hooks	Average catch per 100 hooks									
					Yellowfin	Bigeye	Albacore	Skipjack	Black marlin	White marlin	Broadbill	Sailfish	Shark	Miscella-neous
							March							
8°-11°N. 180°-164°W.	375	20	132,157	620,975	0.12	3.09	0.03	0.02	0.22	0.01	0.01	-	0.06	0.06
4°-12°S. 179°-172°W.	33	2	12,300	54,660	3.01	0.17	1.93	-	0.97	0.03	-	0.01	-	0.04
15°-16°S. 170°-169°W.	10	1	3,720	14,880	2.05	0.03	3.02	-	0.93	0.01	0.01	-	-	0.41
12°-16°S. 154°-146°W.	39	2	17,081	68,324	1.84	0.18	1.52	-	1.57	0.06	0.01	0.06	-	0.32
25°-32°N. 174°-153°W.	93	4	33,384	144,402	0.02	2.13	0.03	-	-	-	0.09	-	0.24	0.07
29°-32°N. 176°-147°W.	65	3	22,048	101,193	0.01	2.84	0.02	-	-	-	0.13	-	0.28	0.07
20°-30°N. 164°-151°W.	28	1	8,136	40,680	0.01	1.93	-	-	-	-	0.08	-	0.38	0.08
7°-24°N. 138°-180°E.	103	6	30,354	128,862	0.53	1.91	0.30	0.04	0.30	0.01	0.01	0.03	0.18	0.30
0°-10°N. 129°-172°E.	741	45	239,638	1,122,954	1.91	0.84	0.02	0.02	0.47	0.01	0.01	0.06	0.06	0.10
2°-10°N. 170°-179°E.	118	6	39,768	185,390	0.59	1.53	0.02	0.03	0.39	0.01	0.01	0.04	-	0.19
2°-16°S. 149°-174°E.	51	3	18,304	91,520	2.96	0.36	0.51	-	0.37	0.01	-	0.06	-	0.08
19°-32°N. 132°-170°E.	287	16	65,884	376,722	0.14	0.21	0.90	-	0.01	-	0.22	-	0.45	0.02
30°-34°N. 134°-139°E.	27	2	4,020	36,180	0.19	0.24	3.13	-	-	-	0.01	-	0.42	0.10
29°-35°N. 137°-152°E.	528	29	105,289	717,847	0.01	0.17	3.86	-	-	-	0.09	-	0.44	0.02
29°-32°N. 145°-180°E.	294	14	71,622	429,419	-	0.27	2.30	-	-	-	0.35	-	0.26	0.01
							April							
9°-12°N. 177°-166°W.	169	9	59,562	283,399	0.24	2.53	0.01	0.01	0.36	-	0.01	0.01	0.08	0.10
0°-4°S. 179°-171°W.	93	4	36,474	160,880	3.11	0.50	0.29	0.01	0.40	0.03	0.01	0.01	0.28	0.29
10°-13°N. 135°-140°E.	24	2	5,554	27,770	1.16	0.62	0.02	-	0.27	0.01	0.03	0.04	0.29	0.09
10°-11°N. 172°-179°E.	66	4	22,009	100,016	0.56	2.17	-	0.05	0.38	0.01	0.01	0.01	-	0.15
0°-11°N. 133°-179°E.	721	42	230,985	1,018,610	2.10	0.82	0.06	0.04	0.50	0.01	0.01	0.07	0.05	0.06
2°-10°N. 170°-179°E.	111	6	39,115	186,275	1.55	1.44	0.22	0.01	0.52	0.02	0.01	0.02	-	0.05
2°-9°S. 159°-179°E.	98	4	32,344	161,720	3.11	0.32	1.09	0.01	0.51	0.04	0.01	0.01	0.09	0.07
30°-31°N. 156°-165°E.	22	1	5,238	26,190	-	0.11	1.05	-	0.02	-	0.68	-	-	-
29°-35°N. 138°-148°E.	278	19	57,870	359,203	-	0.07	2.11	-	-	-	0.11	-	0.65	0.01
29°-35°N. 133°-139°E.	122	17	17,742	112,622	0.09	0.09	0.22	-	0.01	-	0.03	0.04	0.59	0.02
20°-31°N. 130°-173°E.	609	38	130,392	708,863	0.13	0.24	0.25	0.02	0.02	-	0.30	-	0.63	0.07
28°-31°N. 170°-173°E.	50	3	11,180	55,900	-	0.30	0.01	-	-	-	1.17	-	1.39	0.02
							May							
3°-11°N. 178°-168°W.	58	3	21,853	99,965	0.55	2.66	0.02	-	0.44	0.01	0.03	0.02	-	0.05
2°S.-4°N. 179°E.-169°W.	63	4	22,575	115,918	3.16	0.75	0.32	0.01	0.25	0.02	0.02	0.02	0.40	0.04

Table 26.--Japanese commercial longline fishing in the central Pacific during 1955 (data from Nomura 1955-56) (Cont'd)

Area	Stations	Boats	Baskets	Hooks	Average catch per 100 hooks									
					Yellowfin	Bigeye	Albacore	Skipjack	Black marlin	White marlin	Broadbill	Sailfish	Shark	Miscellaneous
							May (Cont'd)							
1°-14°S. 159°-143°W.	48	1 (1)	18,800	77,040	3.11	0.75	2.53	0.32	0.65	0.01	0.02	0.01	-	0.19
14°-16°S. 151°-147°E.	15	1	6,230	31,150	1.63	0.23	2.39	-	1.33	0.04	-	-	-	-
2°N.-6°S. 179°E.-161°W.	349	14	134,617	622,976	4.04	0.40	1.21	0.02	0.27	0.02	0.02	0.02	0.08	0.02
9°-11°N. 174°-180°E.	41	2	14,680	74,500	0.18	2.02	0.02	0.01	0.83	0.01	0.01	0.02	0.32	0.17
2°S.-10°N. 130°-175°E.	548	33	180,684	769,770	2.36	0.78	0.07	0.05	0.50	0.02	0.01	0.07	0.04	0.04
1°-11°N. 169°-180°E.	135	7	49,869	219,665	1.69	1.11	0.32	-	0.53	0.01	0.01	0.01	-	0.26
1°-7°S. 169°E.-179°W.	94	5	34,430	163,750	3.71	0.28	1.46	0.03	0.48	0.03	0.01	0.03	0.08	0.36
30°-34°N. 140°-148°E.	116	8	14,045	92,428	0.07	0.03	0.06	-	0.01	-	0.36	0.01	0.70	0.06
29°-33°N. 136°-137°E.	11	1	2,420	14,520	0.03	0.09	0.02	-	0.03	-	0.10	-	0.21	-
20°-31°N. 130°-162°E.	612	52	139,373	695,462	0.30	0.09	0.02	0.02	0.13	0.01	0.13	0.03	0.53	0.08
26°-28°N. 173°-176°E.	19	1	6,080	30,400	0.02	2.12	0.01	-	0.04	-	0.13	-	-	-
							June							
2°-3°N. 160°-156°W.	20	1	8,400	42,000	5.02	0.27	0.47	-	0.20	-	0.01	0.03	-	0.16
9°-11°N. 177°-168°W.	162	7 (2)	58,450	271,316	0.12	2.12	-	-	0.85	-	0.01	0.01	-	0.05
0°-5°N. 180°-164°W.	175	6 (4)	68,230	316,635	3.04	0.68	0.33	-	0.34	0.02	0.01	-	0.05	0.04
0°(2°N.)-15°S. 179°E.-165°W.	202	12 (1)	72,077	346,451	2.77	0.28	1.70	0.01	0.20	0.02	0.01	0.02	0.03	0.05
13°-17°S. 178°-172°W.	22	2	6,862	31,390	0.51	0.26	1.78	-	0.30	0.01	-	0.06	0.11	0.17
10°-12°N. 172°-177°E.	51	3	14,271	76,716	0.20	2.03	0.13	0.02	0.79	0.01	0.01	0.07	-	0.03
0°-9°N. 140°-167°E.	181	11	57,216	265,282	2.08	0.66	0.02	0.02	0.39	0.01	0.01	0.07	0.08	0.03
1°S.-11°N. 170°E.-179°W.	202	10 (1)	73,315	336,977	2.26	0.95	0.08	0.02	0.52	0.01	0.01	0.01	0.06	0.04
1°-8°N. 145°E.-178°W.	62	3 (1)	23,392	108,160	3.79	0.18	1.01	0.01	0.29	0.01	-	0.15	0.13	0.19
20°-30°N. 129°-157°E.	352	25	98,327	472,191	0.28	0.16	0.01	-	0.22	-	0.22	0.02	1.13	0.12
							July							
2°-5°N. 160°-152°W.	49	3	19,175	84,740	5.29	0.74	0.08	0.06	0.21	0.03	0.01	0.01	0.25	0.08
5°-11°N. 178°-174°W.	72	4	26,536	132,680	0.05	1.79	-	-	0.77	0.01	0.01	-	0.07	0.17
2°S.-4°N. 180°-167°W.	94	5	36,260	163,825	3.79	0.33	0.09	0.03	0.28	0.02	0.01	0.01	0.17	0.04
1°N.-11°S. 179°-164°W.	109	9	36,458	172,830	2.62	0.33	1.92	0.03	0.12	0.02	0.01	0.03	0.15	0.19
10°-11°N. 170°-171°E.	14	1	4,760	23,800	0.24	1.72	-	-	1.16	0.01	0.01	0.01	-	-
1°-9°N. 141°-171°E.	102	7	33,512	143,098	1.89	0.91	0.02	0.02	0.54	0.01	-	0.03	0.01	0.05
1°-10°N. 171°E.-179°W.	124	6	47,861	205,584	1.80	0.71	0.01	0.01	0.84	0.01	0.01	0.01	0.02	0.10
2°-16°S. 144°-179°E.	23	2	8,940	35,760	2.44	0.22	0.86	-	0.21	0.10	0.03	0.08	-	0.08

Table 26.--Japanese commercial longline fishing in the central Pacific during 1955 (data from Nomura 1955-56) (Cont'd)

Area	Stations	Boats	Baskets	Hooks	Average catch per 100 hooks									
					Yellowfin	Bigeye	Albacore	Skipjack	Black marlin	White marlin	Broadbill	Sailfish	Shark	Miscellaneous
							July (Cont'd)							
22°-26°S. 171°-176°E.	55	2	21,359	93,091	0.82	0.26	4.68	0.04	0.10	0.01	0.05	-	0.28	0.09
34°-38°N. 156°-169°E.	52	3	14,360	66,590	-	0.53	0.01	-	0.05	-	0.01	-	1.58	0.03
33°-38°N. 142°-156°E.	15	1	2,676	12,092	-	0.50	-	-	0.09	-	0.04	-	0.88	0.11
22°-30°N. 139°-142°E.	14	1	4,150	16,600	0.55	0.04	-	-	0.56	-	0.09	-	1.22	0.20
							August							
37°-41°N. 180°-174°W.	72	3	26,346	101,126	-	1.20	0.37	-	0.01	-	0.02	-	0.55	0.02
25°-26°N. 174°-160°W.	31	2	8,508	38,254	0.05	1.04	0.14	-	0.28	-	0.01	0.01	-	0.08
4°-10°N. 179°E.-167°W.	92	5	35,013	145,330	1.31	1.41	-	0.01	0.94	-	0.01	-	0.11	-
0°-6°N. 180°-157°W.	79	3 (1)	28,958	133,045	2.00	0.59	0.02	0.04	0.53	0.02	0.01	0.04	0.47	0.09
0°-11°S. 173°-167°W.	21	2	7,674	38,370	1.19	0.20	1.23	0.01	0.11	0.01	-	-	0.07	0.08
3°-9°N. 156°-170°E.	28	2	8,985	35,940	1.43	0.41	0.09	0.05	0.63	-	-	-	0.86	0.07
2°-8°N. 173°E.-178°W.	89	4	32,650	153,890	1.02	0.63	-	0.03	0.89	-	-	-	0.17	0.06
1°-15°S. 142°-169°E.	38	2	14,018	65,172	2.08	0.35	0.39	-	0.28	0.04	-	0.03	0.06	0.05
15°-28°S. 152°E.-179°W.	168	5 (1)	68,118	286,060	1.30	0.24	4.41	-	0.06	0.04	0.12	-	-	0.06
37°-41°N. 156°-180°E.	44	2	13,170	52,360	-	0.91	0.19	-	0.03	-	0.01	-	0.89	0.03
							September							
29°-41°N. 180°-155°W.	290	13 (1)	97,577	425,237	0.22	1.58	0.47	-	0.08	-	0.02	-	0.22	0.05
5°-7°N. 143°-140°W.	17	1	6,130	24,520	2.89	5.68	-	0.23	0.38	0.04	-	0.07	1.29	0.33
4°-10°N. 179°E.-164°W.	179	9	66,987	309,176	0.76	1.51	-	-	0.86	-	0.01	0.01	-	0.04
9°-19°N. 136°-138°E.	15	1	4,050	16,200	0.94	0.44	0.01	-	0.36	0.01	0.01	0.04	0.82	0.23
3°-9°N. 131°-176°E.	104	6	33,845	145,965	0.79	0.88	-	0.03	0.56	-	-	0.07	0.17	0.04
3°-10°N. 171°-179°E.	51	2 (1)	16,914	80,828	0.88	1.09	-	-	0.83	-	0.02	0.02	0.24	0.08
0°-15°S. 150°-172°E.	159	9	56,123	258,765	1.59	0.28	0.88	0.01	0.23	0.07	0.03	0.11	0.15	0.05
17°-27°S. 147°-173°E.	270	7	105,209	429,104	1.14	0.19	3.01	-	0.06	0.16	0.12	-	0.08	0.08
38°-44°N. 154°-178°E.	293	13	82,784	337,653	0.01	0.52	0.05	-	0.02	-	0.11	-	0.75	0.04
37°-41°N. 151°E.-179°W.	376	19	104,515	437,189	0.01	0.78	0.60	-	0.03	-	0.04	-	0.46	0.06
							October							
28°-37°N. 179°-153°W.	313	13 (2)	103,983	451,734	0.09	1.59	0.04	-	0.10	-	0.02	-	0.16	0.07
27°-32°N. 179°-158°W.	274	13	93,938	400,741	0.11	1.21	0.02	-	0.08	-	0.03	-	0.26	0.09
6°-8°N. 141°-137°W.	49	2	18,985	94,925	1.27	3.69	0.07	-	0.76	0.03	0.03	0.06	0.07	0.11
6°-11°N. 159°-140°W.	145	6	55,732	230,788	1.22	2.42	-	-	0.46	0.01	0.02	0.03	0.31	0.08

Table 26.--Japanese commercial longline fishing in the central Pacific during 1955 (data from Nomura 1955-56) (Cont'd)

Area	Stations	Boats	Baskets	Hooks	Average catch per 100 hooks									
					Yellowfin	Bigeye	Albacore	Skipjack	Black marlin	White marlin	Broadbill	Sailfish	Shark	Miscellaneous
							October (Cont'd)							
4°-11°N. 174°-162°W.	116	6 (1)	42,535	194,369	0.47	1.34	0.01	-	0.64	-	0.01	0.01	0.04	0.03
1°-7°N. 180°-175°W.	46	2	16,459	75,505	3.01	0.48	0.09	-	0.35	0.02	0.02	-	-	0.04
19°-22°S. 178°E.-176°W.	20	1	6,600	39,600	0.77	0.51	3.10	-	0.12	0.01	0.03	-	0.18	0.39
17°-20°N. 132°-134°E.	13	1	3,380	23,660	1.38	0.40	0.22	-	0.18	0.01	0.02	-	-	0.43
10°-11°N. 173°-174°E.	11	1	4,400	22,000	0.64	0.23	0.03	-	0.29	0.04	0.03	0.05	-	-
0°-10°N. 132°-174°E.	69	5	24,153	104,193	1.08	0.53	0.12	0.01	0.49	0.02	0.02	0.10	0.43	0.04
1°-11°N. 169°-180°E.	144	5 (1)	54,429	244,151	0.46	0.88	-	0.02	0.52	-	-	0.02	0.26	0.06
6°-15°S. 144°-174°E.	190	8	71,725	346,350	1.73	0.27	0.67	0.02	0.30	0.30	0.02	0.03	0.03	0.19
16°-28°S. 146°-160°E.	194	7	68,206	336,714	1.28	0.19	0.83	-	0.17	0.57	0.06	0.01	-	0.05
40°-44°N. 159°-173°E.	77	5	16,653	106,698	-	0.03	0.07	-	0.03	-	0.92	-	2.32	0.06
34°-41°N. 149°E.-179°W.	798	39	213,129	867,613	0.03	0.62	0.81	-	0.05	-	0.04	-	0.64	0.09
							November							
6°-8°N. 140°-133°W.	24	1	9,132	36,528	0.70	2.85	-	-	0.54	0.03	0.06	0.07	0.13	-
5°-9°N. 150°-140°W.	50	2	18,018	78,226	0.76	2.39	-	0.10	0.43	0.02	0.02	0.14	-	0.13
1°N.-3°S. 159°-156°W.	17	1	6,497	32,485	2.69	0.31	0.39	0.16	0.18	0.01	0.01	-	-	0.27
28°-38°N. 178°E.-150°W.	323	13	113,546	504,687	0.05	1.65	0.50	-	0.05	-	0.03	-	0.33	0.06
24°-32°N. 177°-157°W.	175	7 (1)	60,065	261,226	0.09	1.19	0.01	0.03	0.07	-	0.01	-	0.29	0.14
6°-11°N. 180°-166°W.	68	3	26,810	114,460	0.43	1.29	-	-	0.37	-	0.01	0.05	0.16	0.17
1°-7°N. 175°-165°W.	42	2	16,115	80,575	1.02	0.94	-	-	0.08	0.01	-	-	-	-
20°-24°S. 180°-171°W.	59	4	21,654	108,270	0.81	0.35	1.62	-	0.32	0.02	0.02	-	-	0.09
16°-20°N. 132°-136°E.	48	3	12,048	51,942	1.49	0.15	0.15	-	0.19	0.01	0.02	0.02	0.22	0.71
0°-9°N. 133°-172°E.	152	11	50,014	238,384	1.65	0.61	-	0.01	0.60	0.01	0.01	0.07	0.13	0.12
3°-11°N. 166°-174°E.	13	1	4,192	20,960	1.61	1.07	-	-	0.39	-	-	-	0.28	-
0°-6°S. 158°-176°E.	32	2	11,960	59,800	2.54	0.67	0.01	0.19	0.19	0.02	0.01	0.05	0.08	0.03
15°-26°S. 146°-174°E.	53	4	17,640	83,140	1.15	0.07	1.47	-	0.22	1.98	0.02	0.04	-	0.13
33°-41°N. 151°-179°E.	355	20	94,786	452,983	0.03	0.50	0.95	0.02	0.02	-	0.52	-	0.61	0.04
31°-36°N. 150°-180°E.	329	18	83,366	389,689	0.05	1.04	0.93	0.03	0.03	-	0.09	-	0.56	0.08
36°-42°N. 142°-146°E.	26	4	2,558	7,674	-	-	-	-	-	-	0.13	-	3.17	0.07
22°-29°N. 140°-146°E.	67	4	14,295	60,700	0.36	0.65	0.03	-	0.02	-	0.08	-	1.23	0.21
							December							
5°-9°N. 140°-130°W.	108	4	39,079	163,493	0.42	2.56	-	0.01	0.34	0.03	0.04	0.06	0.51	0.19

Table 26.--Japanese commercial longline fishing in the central Pacific during 1955 (data from Nomura 1955-56) (Cont'd)

Area	Stations	Boats	Baskets	Hooks	Average catch per 100 hooks									
					Yellowfin	Bigeye	Albacore	Skipjack	Black marlin	White marlin	Broadbill	Sailfish	Shark	Miscella-neous
					December (Cont'd)									
5°-19°N. 160°-142°W.	60	2	21,582	92,308	0.86	2.85	0.07	-	0.18	0.03	0.01	0.03	0.22	-
14°-16°S. 149°-145°W.	28	1	11,719	46,876	2.39	0.24	3.81	-	1.63	0.01	-	-	-	0.20
14°-16°S. 156°-148°W.	34	1	13,625	68,125	0.99	0.10	2.76	-	1.30	0.01	0.01	0.01	-	-
30°-35°N. 179°-147°W.	356	15	117,373	523,575	0.01	2.16	0.67	0.01	-	-	0.06	-	0.25	0.04
28°-31°N. 179°-176°W.	9	1	2,961	14,805	0.53	0.55	0.34	0.02	0.11	-	0.02	-	1.62	0.14
8°-19°N. 180°-165°W.	63	2	24,350	102,930	0.36	1.31	0.04	-	0.18	-	-	0.03	0.38	0.18
19°-25°S. 180°-173°W.	24	1	8,623	43,115	1.15	0.07	0.93	-	0.52	0.08	0.02	0.01	-	0.13
1°-6°N. 140°-170°E.	20	1 (1)	6,949	32,311	2.24	0.72	-	0.07	0.40	-	0.03	0.04	0.66	0.12
5°-11°N. 162°-174°E.	24	2	7,390	36,950	0.40	0.85	0.01	-	0.51	-	0.01	-	0.30	0.09
1°-14°S. 143°-155°E.	58	3	21,773	100,475	3.68	0.21	0.02	-	0.33	0.09	0.02	0.42	0.21	0.04
15°-23°S. 146°-157°E.	79	4	28,286	136,486	1.88	0.11	0.63	-	0.22	1.29	0.01	0.02	0.08	0.18
31°-36°N. 150°-179°W.	270	12	75,362	365,252	0.01	0.62	2.31	0.02	0.01	-	0.09	-	0.35	0.03
34°-39°N. 163°-173°E.	61	3	19,665	87,230	0.01	0.61	0.93	-	-	-	0.74	-	1.26	0.01
35°-36°N. 141°-142°E.	13	1	946	5,676	-	-	-	-	-	-	-	-	2.73	0.26
21°-30°N. 142°-176°E.	75	4	21,578	95,052	0.14	2.31	0.03	-	0.01	-	0.02	-	0.43	0.09

Notes on the Biology of the Wahoo in the Line Islands

Edwin S. Iversen[1] and Howard O. Yoshida[2]

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Notes on the Biology of the Wahoo in the Line Islands

EDWIN S. IVERSEN[1] and HOWARD O. YOSHIDA[2]

INCIDENTAL CATCHES of wahoo, *Acanthocybium solandri* (Cuvier and Valenciennes), have been made by the Pacific Oceanic Fishery Investigations, a branch of the U. S. Fish and Wildlife Service, during experimental tuna fishing conducted from 1950 to 1956. The exploratory fishing, which extended from 180° to 130°W. longitude and from 10°N. to 13°S. latitude, has been carried out both close to the islands and in the open sea. The bulk of our wahoo data came from the Line Islands, which from south to north are: Starbuck, Malden, Jarvis, Christmas, Fanning, Washington, and Palmyra islands, and Kingman Reef. They extend in a general northwesterly direction from 5°S. latitude and 155°W. longitude to 7°N. latitude and 163°W. longitude. Although there is no organized fishery in the islands, the copra plantation workers (Gilbertese and Ellice islanders) use beach seines to capture a variety of lagoon and reef fishes and hand lines to catch an occasional tuna or wahoo.

Most of the published reports dealing with the wahoo are brief and are concerned primarily with its occurrence and distribution. The presence of wahoo was first noted in the Line Islands by Fowler (1938: 277). Rosa (1950: 75–77) lists a number of references which are of interest principally to taxonomists. In general the biology of the species is poorly known and has not been previously considered in the central Pacific.

The wahoo, a member of the order Scombriformes, is a slender, streamlined fish with a sharp pointed head (Fig. 1). The mouth is large and is armed with razor-sharp teeth. Wahoo may weigh over 130 pounds and reach a length of nearly 7 feet. The body is steel-blue above and pale blue below. A series of bluish-black vertical bars, which fade soon after death, are present on the sides of the body. These fish are said to be very rapid swimmers and to make spectacular leaps out of the water.

The species is cosmopolitan in tropical and subtropical areas, and ranges at least as far north as Hawaii, where it is called "ono." Jenkins (1904: 441) examined wahoo in the Honolulu Market and reported that, "This is the first record of the species in Honolulu." In Hawaii today the species is of some slight importance as a sport fish. It is also sold commercially on the fresh fish market in Honolulu, but is of secondary importance. In 1953 the catch of 50,813 pounds during the year was sold for $11,166.94.

METHODS

The majority of fish available for this study were taken on standard surface trolling gear which is described by Bates (1950). This method of trolling employs about six lines attached to two long poles extending outboard, one from either side of the vessel. Trolling was mainly carried out from approximately 200 yards to 3 miles from the fringing reefs of the various islands. Some catches were also made on longline (flagline) gear, described by Niska (1954). Longline gear, which fishes well below the surface, was generally

[1] The Marine Laboratory, University of Miami, Coral Gables, Florida. (Formerly Fishery Research Biologist, U. S. Fish and Wildlife Service, Honolulu, T. H.)

[2] Fishery Research Biologist, U. S. Fish and Wildlife Service, Honolulu, T. H. Manuscript received June 18, 1956.

Fig. 1. Wahoo captured by surface trolling in the Line Islands.

used in the open ocean, but some longline stations were occupied as close as 5 to 10 miles from land.

Length measurements were made in millimeters, using calipers. The fixed arm was placed on the tip of the upper jaw with the mouth closed, and the sliding arm of the caliper was placed at the fork of the caudal fin, being careful to depress the fleshy flap (Marr and Schaefer 1949: 242). Weights were taken in pounds, using a steelyard rigged to a davit on the deck of the vessel. Some difficulty was encountered in accurately weighing the fish when the vessel was under way, but most weights were taken when the vessel was in smooth waters or at anchor.

In preparing length-frequency distributions the lengths were first combined in 4-cm. groups and then smoothed by a moving average of three. Modal groups in these distributions are defined as the size classes with the highest frequencies in the smoothed distributions. Where several adjacent size classes are similar in height after smoothing, the center of these size classes is designated as the mode.

Stomach contents of the fish were recorded in the field as soon as possible after the fish were captured. The few parasites returned to the laboratory for examinations were preserved in 10 per cent formalin.

Measurements of ova for spawning and fecundity analysis were made with a dissecting microscope, employing a micrometer eyepiece measuring in units of 0.023 mm. The eggs were not perfectly symmetrical, so to avoid selection the "diameter" measured was the distance between two lines of the micrometer tangent to the eggs, the micrometer being held in one position during a series of measurements, following the method of Clark (1934: 7).

AVAILABILITY

Wahoo do not appear to form large compact schools. This simplifies the problem of

estimating their availability. Kishinouye (1923: 412) states that wahoo do not "make a school." Taylor (1951: 278), in discussing wahoo off North Carolina, reports that they do not form schools but that males and females group in pairs at spawning time. From our trolling catches close to shore it seems that this species tends to form small, loose, feeding aggregations, since we found that occasionally several wahoo would hit the lures simultaneously. Chapman (1946: 166) believes that they may form schools, for some of the wahoo he caught near Palmyra Island had frayed caudal fins, which he attributed to crowding in schools.

Some general knowledge of the vertical and horizontal distribution of wahoo is important when estimating the availability of this species. These aspects of the distribution can be roughly inferred from a comparison of longline catches and troll catches. The longline catches are small both close to land and in the open ocean. For example, Murphy and Shomura (1953*a*, 1953*b*, 1955) and Shomura and Murphy (1955) record only 59 wahoo captured on 14 POFI experimental longline fishing cruises involving numerous stations, some close to land. This figure suggests that wahoo are never abundant at the depths fished by this gear (200–600 ft.). Trolling operations were much more productive, but only close to land. Only 12 wahoo were caught during 5,500 hours of surface trolling in the open sea, more than 60 miles from land (Murphy and Ikehara 1955: 14). In contrast, within a few miles of land in both the Hawaiian Islands and Line Islands surface catches have averaged about 1 wahoo per hour (Table 1). From this information we infer that the wahoo prefer shallow depths and are more abundant close to land.

Even near islands wahoo are not very abundant in the central Pacific. This is suggested by the low catch rates from surface trolling around the Hawaiian and Line islands (Table 1). The troll catches obtained near the Line Islands during all seasons of the year indicate that the species does not occur there in sufficient numbers to support a profitable commercial fishery. This is also true in Hawaii (Welsh 1949*b:* 29). Neither does the wahoo appear to be very abundant in the Atlantic, at least off North Carolina, where Taylor (1951: 278) states that the population is small.

It is interesting to note from the Line Islands data (Table 1) that wahoo and yellowfin tuna, *Neothunnus macropterus* (Temminck and Schlegel), have a similar pattern of seasonal variation in availability. This similarity could indicate that environmental or other factors

TABLE 1
RESULTS OF SURFACE TROLLING FOR WAHOO AND YELLOWFIN TUNA IN WATERS OF THE HAWAIIAN AND LINE ISLANDS

TIME	HOURS TROLLED	AVERAGE NUMBER OF LINES	WAHOO		YELLOWFIN	
			Number	Catch per hour	Number	Catch per hour
Hawaii						
Year around, 1947–48 (Welsh 1949b)	307	7.0	20	0.07	23	0.08
Line Islands						
April-June 1950 (Bates 1950)	285.5	6.1	178	0.62	882	3.09
March-April 1955	142.5	5.0	274	1.92	438	3.07
May-June 1955	116.0	6.0	135	1.16	100	0.86
July-August 1955	105.0	6.0	83	0.79	24	0.25
September-October 1955	182.0	6.0	245	1.35	171	0.94
November-December 1955	108.0	6.0	144	1.33	64	0.59
January-February 1956	133.5	6.0	267	2.00	148	1.10

influence both species similarly and are of greater importance than inter-specific competition for food, though both appear to feed on similar animals.

REPRODUCTION

In samples from the Line Islands, at all times of the year the percentage of males tends to be higher in the northern islands than in the southern islands (Fig. 2). This consistent trend or gradient suggests a migration of wahoo to maintain itself, unless there is varying differential mortality between sexes among areas, which seems unlikely. Such a gradient might be related to spawning movements but we are unable to describe them.

The wahoo in the Line Islands appear to spawn over an extended period of time, as is common with fish found in tropical waters.

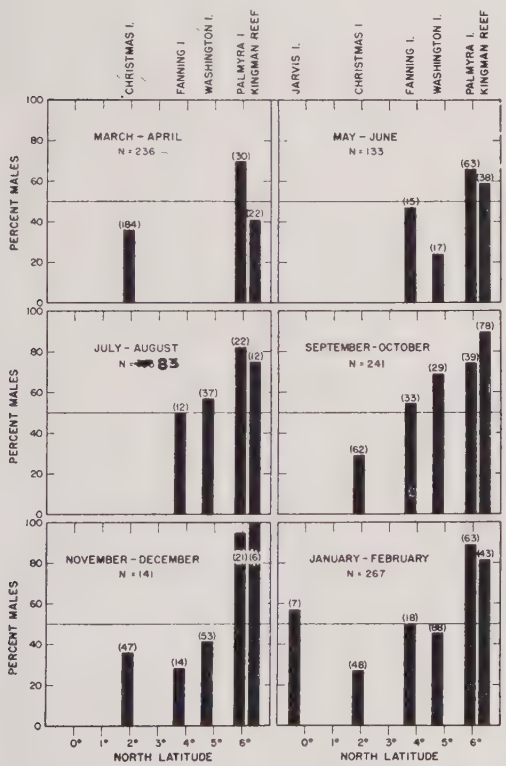

Fig. 2. Percentage of male wahoo by trolling areas, March 1955 to February 1956. (The number in each sample is shown in parentheses).

Cursory field examination of 80 females in March and of 143 in November and December, using categories devised by Marr (1948: 201),—i.e., immature, ripening, ripe, spawning, and spawned out—revealed all stages of maturity during both periods.

In order to estimate the number of eggs per spawning the size frequency distribution of ova in an apparently ripe ovary was determined for a fish of 131 cm. fork length (Fig. 3). Only eggs larger than 8 micrometer divisions, or 0.184 mm., were measured. An abundance of undeveloped or primitive eggs was present in the ovary, but most of these were not measured. The group 0.184–0.46

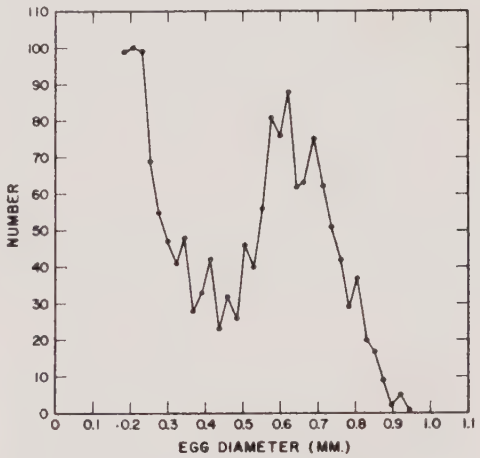

Fig. 3. Frequency distribution of egg diameters from a single female, 131 cm. fork length, captured May 1955 at Fanning Island.

mm. contained the larger of these "stockpile" eggs; the group from about 0.46 mm. to 0.94 mm., with a prominent mode at 0.62 mm. appeared to be maturing eggs. This latter group of eggs may be likened to the "type B" or developing eggs described by Tester and Takata (1953: 42) from the aholehole, *Kuhlia sandvicensis*. This one specimen showed no clear evidence of more than one mode among the developing eggs. The maturing group of eggs (> 0.46 mm.) in the ovaries of this female wahoo was estimated to number about 6.1 million. This estimate was obtained by weighing the formalin-preserved

(wet) ovaries, weighing a wedge-shaped section from one of the ovaries, and counting the number of eggs in the most mature group in this sample. The total number of mature eggs in both ovaries was then calculated by simple proportion.

This estimate of 6.1 million eggs per spawning is comparable in order of magnitude to the amount of spawn released by some other related species. Yuen (1955: 18) computed the number of eggs extruded in one spawning of a bigeye tuna, *Parathunnus sibi* (Temminck and Schlegel), in the Pacific to be 2.9 to 6.3 million; June (1953: 63) estimated the number of eggs per spawning of a yellowfin sampled in Hawaii to be 2 to 8 million. Both authors found that the number of eggs spawned increased, in general, with increase in size of fish. This probably holds true for the wahoo.

FOOD HABITS

Of the 235 stomachs examined, 115 (48.5 per cent) were empty. This relatively large number of empty stomachs may be due to regurgitation on capture. The wahoo struggles violently on the trolling line and may regurgitate food while being landed and killed. As some of the stomach contents were probably incomplete, an elaborate analysis of the food based on percentage by volume was not undertaken. Rather the analysis was confined to frequency of occurrence of the various food items.

Fish remains have a high frequency of occurrence among the food items (Table 2), and perhaps beyond their true significance since fish bones are slow to digest and hence persist longer in the stomachs than readily digested items. In both time periods (March, and November–December) mackerel scad, squid, and skipjack appear to be of importance in the food, with mackerel scad being the major item.

A much greater variety of food than is indicated by Table 2 is probably consumed by the wahoo. Very small items could have been overlooked. On infrequent occasions specimens were on deck for several hours prior to the examination of the stomachs, and the

TABLE 2
STOMACH CONTENTS OF 235 TROLL-CAUGHT WAHOO CAPTURED DURING MARCH, AND NOVEMBER-DECEMBER, 1955

FOOD ITEMS	FREQUENCY OF OCCURRENCE		PER CENT FREQUENCY OF OCCURRENCE	
	March	November-December	March	November-December
Items identifiable				
Squid (*Loligo* sp.)	6	3	18.2	13.0
Skipjack (*Katsuwonus pelamis*)	4	6	12.1	26.1
Pomfret (Bramidae)	1	1	3.0	4.4
Puffer (Tetraodontidae)	2	2	6.1	8.7
Mackerel scad (*Decapterus* [*psinnulatus*])	19	9	57.5	39.1
Flying fish (*Cypselurus* sp.)	1	..	3.0	...
Lantern fish (Myctophidae)	..	1	...	4.4
Sunfish (*Ranzania truncata*)	..	1	...	4.4
Total	33	23	99.9	100.1
Entire sample				
Empty stomachs	34	81	39.1	54.7
Fish remains not identifiable	20	44	22.9	29.7
Food remains identifiable	33	23	37.9	15.5
Total	87	148	99.9	99.9

identity of the more readily digestible forms could be lost during this time. Aside from these difficulties, it seems likely that the data in Table 2 provide a reasonably good picture of the food throughout the year. We do not believe there is much seasonal change in the fauna of the tropical Pacific.

The results of other studies suggest the diet of wahoo is similar throughout its range. Welsh (1949*a:* 22) made a preliminary examination of the food of wahoo in the Hawaiian Islands, using a rating system which considered total bulk of food, total number of food items, and the total number of times food was found in individual stomachs. Of the 17 stomachs he examined, 10 were empty. Those containing food held fish and squid. The food habits of the wahoo near Japan would seem to be nearly the same as in the Line Islands, for Kishinouye (1923: 412) states that they "feed on calamaries [squid] and pelagic fish."

LENGTH FREQUENCY ANALYSIS

An examination of the sizes of wahoo in our catches will contribute to our understanding of the biology of this species. In the Line Islands we sampled only a segment of the known size range of the species for small fish were not taken and much larger sizes have been recorded from other areas. Hosaka (1944: 69) reports a 124¾-pound wahoo taken on sport fishing gear off the island of Oahu, and LaMonte (1952: 9) reports a world record for wahoo as 133½ pounds (6 ft., 11 in.) caught in the Bahamas in 1943.

The size distribution of longline-caught wahoo is similar in most respects to that of fish taken on trolling gear. The longline catches, most of which are from the open sea, were made over several years at all months of the year and show a prominent mode at 128 cm. and a lesser mode at 146 cm. (Fig. 4). These fish range from 54 to 198 cm., with the majority between 106 and 162 cm. The measurements of troll-caught wahoo, taken mostly within 3 miles of land, during 1950,

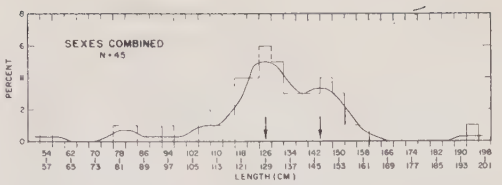

Fig. 4. Size frequency distribution of longline-caught wahoo, October 1950 to March 1955. (Smoothed by a moving average of three.)

1951, 1955, and 1956 show a similar size range, from 98 to 174 cm., and a similar distribution of sizes. It would appear then that both fishing methods sampled the same segments of a common population.

Samples of wahoo from some islands show differences in length distribution between sexes. An example of this in distributions of wahoo taken at Christmas Island during March and April 1955 (Fig. 5) shows a slight displacement of modes. In the male distribution there is a small mode at approximately 114 cm. and a dominant mode at approximately 134 cm.; in the female distribution there is a dominant mode at about 128 cm.

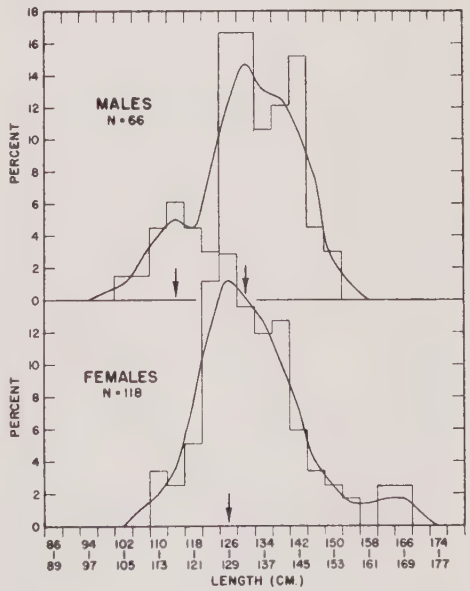

Fig. 5. Size frequency distribution of troll-caught wahoo from Christmas Island during March-April 1955. (Smoothed by a moving average of three.)

and a suggestion of a mode at approximately 164 cm. This suggests a differential growth rate between the sexes.

Wahoo show size variation associated with changes in latitude, as has been described for other scombrid fish. For example, Nakamura (1952: 101) found that the average weight of yellowfin tuna increased with latitude both to the north and south of the equator between the west coast of Sumatra and the Nicobar Islands. With respect to wahoo, the relative abundance of the larger fish appears to decrease from Christmas Island in the south to Palmyra Island and Kingman Reef in the north. This is accompanied by an increase in the numbers of smaller fish from south to north, these trends appearing in both the male and female length distributions (Fig. 6). The indications are that the wahoo are not distributed over the area in random fashion with respect to either size (Fig. 6) or sex (Fig. 2). Unless each area has a separate population with a different growth rate and sex ratio, there must be differential movement of individuals or groups in order to maintain the observed size and sex gradients. This movement, however, need not necessarily be confined to the study area.

This nonrandom distribution of the wahoo makes it almost impossible to study growth by the method of progression of dominant modes in size frequencies because of the great difficulty in obtaining representative samples. Therefore such studies were not attempted.

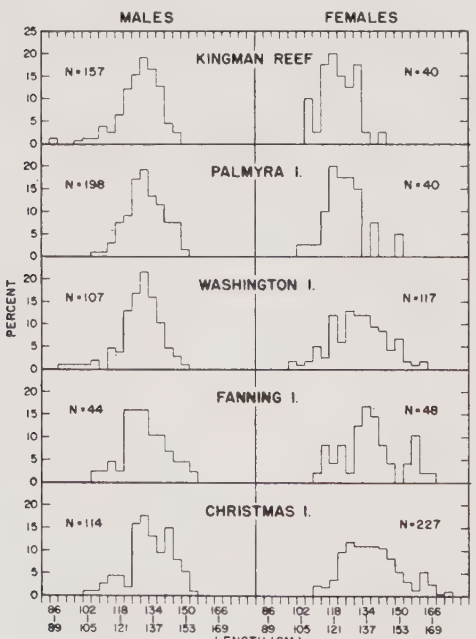

FIG. 6. Length frequency distributions of wahoo by areas, March 1955 through February 1956.

LENGTH-WEIGHT RELATIONSHIP

As no significant difference in the length-weight relationship was noted between sexes, the data were combined to calculate the following regression equation which describes this relationship in the wahoo: Log weight = $-9.4199 + 3.50583$ log length, where weight is in pounds and length in millimeters. The mean weights for given lengths may be determined from the smooth curve shown in Figure 7. This large exponent, 3.50583, reflects the elongate, slender shape of the wahoo. As one would expect for a fish of this shape, a small increase in weight yields a relatively large increase in length. On the other hand

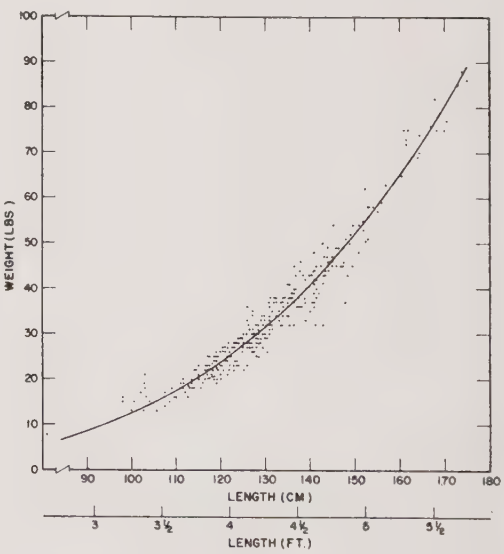

FIG. 7. Length-weight relationship for wahoo from the Line Islands, February 1951 to June 1955. Regression curve fitted by the equation: Log weight = $-9.4199 + 3.50583$ log length.

stout-bodied fish, such as some of the tuna, have a considerably smaller exponent. Examples are: yellowfin from Costa Rica, which have an exponent of 2.940 (Schaefer 1948: 119); and bigeye tuna, *Parathunnus sibi* (Temminck and Schlegel), sampled in Hawaii, which have an exponent of 2.9304 (Iversen 1955: 2).

PARASITES

Although no diligent search was made for parasites, the list given in Table 3 indicates that the wahoo is rather heavily parasitized. In the course of the examination of food items, trematodes about one inch in length when partially contracted were regularly noted at the posterior end of the stomach. Nigrelli and Stunkard (1947: 188) have carefully examined the genus *Hirudinella* and, on the basis of 33 specimens taken from wahoo captured in both the Atlantic and Pacific oceans, regard all forms of this giant trematode in the wahoo as belonging to a single species, *H. ventricosa* (Pallas).

In the 220 stomachs examined during March and November–December 1955 the number of giant trematodes per stomach ranged from 0–17 (Table 4). In all except the largest fish, two trematodes per fish were most commonly encountered, suggesting that this number represents a physiological equilibrium between host and parasite. On the other hand in the largest length group (160–179.9 cm.), four trematodes per stomach were commonly found.

SUMMARY

1. The availability of wahoo caught by trolling and longline fishing indicated the existence in the Line Islands of a small population that was most abundant in shallow water within a few miles of land.
2. Males were relatively more abundant in catches from the more northerly islands than in those from the more southerly islands.
3. Examination of wahoo gonads showed all

TABLE 3
Parasites of wahoo from the Line Islands, 1955

Parasite	Site of infection	Numbers present per wahoo	Rate of infestation	
			Per cent	Number of wahoo examined
Trematoda				
Neothoracocotyle acanthocybii (Meserve)[1]	Between gill filaments	Numerous	(high)	...
Didymocystis acanthocybii Yamaguti[1]	Head inside gill covers	Numerous cysts—2 worms/cyst	51.0	104
Hirudinella ventricosa (Pallas)	Caudal end of the stomach	0–17	98.2	220
Nematoda	Mass of worms embedded in belly wall	Many	(slight)	...
Copepoda				
Brachiella sp.	Within joint of pectoral fins	2 in each joint	98.3	118
Gloiopotes sp.	Outside surface of body and caudal fins	Many—variable	54.2	96
Pennella sp.	Embedded in belly wall with hind portion protruding	1 or 2	9.8	92

[1]Trematodes kindly identified by Dr. H. W. Manter, University of Nebraska, Lincoln.

TABLE 4
NUMBER OF GIANT TREMATODES IN STOMACHS OF WAHOO, BY HOST SIZE

NUMBER OF WORMS PRESENT	FREQUENCY OF OCCURRENCE BY HOST SIZE (CM.)							
	100–119.9		120–139.9		140–159.9		160–179.9	
	No.	%	No.	%	No.	%	No.	%
0	..	...	3	2.4	1	1.4	..	...
1	..	...	7	5.7	7	9.7	1	7.7
2	10	90.9	90	72.6	41	56.9	3	23.1
3	..	...	19	15.3	12	16.7	1	7.7
4	1	9.1	3	2.4	8	11.1	6	46.2
5	..	...	1	0.8	1	1.4	1	7.7
6	..	...	1	0.8	..	...	1	7.7
8	..	...	..	...	1	1.4	..	...
17	..	...	..	...	1	1.4	..	...
Total	11	100.0	124	100.0	72	100.0	13	100.1

stages of maturity present. The number of mature eggs in a single female was estimated at over six million.

4. The wahoo taken close to the islands showed little variety in their diet as judged by stomach contents. Of the identifiable food material the main items were mackerel scad, skipjack, and squid.
5. An examination of size frequency distributions from the Line Islands area revealed that the females attain a larger size than the males, and there is some suggestion that the two sexes grow at different rates. No attempt to estimate growth by modal progression is made since there are indications that the samples were not representative of a homogeneous population unit.
6. A length-weight relationship for wahoo from the Line Islands is given by the equation:

   Log weight (pounds) = −9.4199 + 3.50583 log length (millimeters).
7. The wahoo was found to be parasitized by trematodes, nematodes, and copepods.

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